EXPLORATION OF THE PHENOTYPIC VARIATION IN HAWAIIAN HERITAGE SWEET POTATO

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ABSTRACT

Sweet Potato (*Ipomea batatas*) is a tropical morning glory that can reproduce both sexually and asexually and is an essential staple throughout the Pacific and locally in Hawai'i. Despite local agronomic and cultural importance, importation competition, the rising cost of production, and lack of diversity in commercially grown cultivars are forcing many small and organic sweet potato producers out of the industry. Developing cultivars that produce competitively to the commercial standard Okinawa from traditional Hawaiian varieties can help small and organic growers find their market niche. 'Hawaiian Heritage' lines were compared in trials in three environments to assess the potential of newly developed breeding material. Ten phenotypes determined as necessary through communication with an indigenous-led community organization (Waimanalo Research Hui). These were used to create a decision tree to assess performance and make selections. Two potential selections (HM 26 and HM 34) that were comparable to the commercial standard and breeding lines that may have further interest for unique colors, were identified (e.g., HM 32 and HM 17). New market niches could help raise income and allow the more vulnerable growers to stay in the sweet potato industry, further enhancing the work and impact of the variety of development in this project. The selected breeding lines are good candidates for larger-scale testing in the commercial growing areas on the big island. Market analysis on the reception of these lines and to increase awareness before release can also be done.

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CHAPTER 1: THE HISTORY OF SWEET POTATO (*IPOMEA BATATAS (L.) Lam.*)

1.1 Introduction

Sweet Potato was one of the original plants, termed canoe plants, brought by Polynesian explorers when they settled Hawai'i (Hartshorn et al., 2006) approximately 1400 years ago (Ladefoged et al., 2005). Sweet Potato was a major element of traditional Hawaiian agriculture that has helped feed the population of Hawai'i for centuries (Kurashima et al., 2019). As recently as the 1990s, sweet Potato was an important export crop for Hawai'i (Valenzuela et al., 1994). Despite being an important staple and export crop throughout Hawaiian history, smaller-scale local growers now face a range of issues making commercial cultivation difficult on smaller scales (Pulakkatu-thodi et al., 2018). These issues include a high cost of production in Hawai'i (influenced by introduced pests, inefficient mechanization and high land costs) combined with cheaper imports (Pulakkatu-thodi et al., 2018), this translates into poor profitability and has caused decreased acreage in cultivation and decreased the number of sweet potato growers in recent decades. The low value of fresh market roots (the unprocessed harvest for grocery stores and wholesalers) necessitates conversion of the harvest into value-added products such as chips, fries, or beer, is frequently cost-prohibitive for small-holder farmers (Krishnakumar et al., 2009).

Hawai'i, specifically the University of Hawai'i, has a long history of breeding and selection in sweet Potato (Poole, 1952). However, recent work in breeding, agronomic, and nutrition research in Hawai'i has principally used sweet potato germplasm from Asia and other parts of the United

States (e.g., Huang et al., 1999). Besides research into traditional Hawaiian agricultural systems (Hartshorn et al., 2006), traditional varieties of sweet potatoes from Hawai'i have not been used extensively in breeding and agricultural research. The lack of widespread use and cultivation of traditional varieties places their future at risk as extant collections are relegated to potentially vulnerable botanic gardens and personal collections. Despite the best efforts, these collections are prone to neglect, abandonment, and mislabeling (Winnicki et al., review).

1.2 Botanical Description

Sweet Potato (*Ipomea batatas*) is a domestic tropical morning glory in the *Convolvulaceae* family within the genus Ipomoea. Sweet Potato has a center of origin and domestication in Central America and possibly Northern South America (Khoury et al., 2015). The plant is a tropical and subtropical adapted vining herbaceous perennial. It is cultivated as an annual throughout its range. With thousands of cultivars around the world, phenotypic characteristics such as growth form, the vigor of the vining habit and leaf morphology are highly variable across domestic and feral populations. Leaf, vine, and root skin and parenchyma color are all highly variable as well as flowers (Huaman, 1992). While the leaves and shoots can be consumed as a vegetable, the lateral storage roots are generally the focus for crop production. Like other traits, root shape; and formation within the root system are highly variable. Storage root formation can occur in closed clusters, open clusters, dispersed throughout the root system, and very dispersed throughout the root system (Huaman, 1992). The plant's physiochemical attributes and nutritional traits also vary between cultivars (Mendoza et al., 2018).

1.3 Sweet Potato Genetics

Sweet Potato is an autoallohexaploid with evidence of a hybridization event between the closely related *Ipomea tobascana* and *Ipomea fitida* followed by chromosome doubling being the origin of the species (Srisuwan et al., 2006). These parental species have overlapping ranges in Central America, the region with the highest Ipomea diversity. Few species have a native range outside of the Americas (Khoury et al., 2015; Huaman, 1992). The domestic form has a pantropical distribution, having widespread dispersal through human migration and trade throughout the tropical and subtropical Americas before European colonization (Khoury et al., 2015). Sweet Potato is an obligate outcrossing species that require insects for pollination. Breeding populations are often established by creating poly cross blocks, planting maternal half-sib families, then selecting superior clones derived from these families (Yamakawa, 1998). In commercial cultivation, plants are propagated from vegetative cuttings. These are usually from stem cuttings or the adventitious sprouts from the storage root known as slips (Yamakawa, 1998).

Dispersion and domestication led to four major population groupings of sweet Potato that became established outside of the original range (Roullier et al., 2013). Genetic bottlenecks form influenced by clonal propagation and demographic effects correlated to the region of the Americas introduced populations originated. These introductions have been traced using genetic and linguistic comparisons (Roullier et al., 2013). Understanding the different population groups helps breeding programs to plan crosses. Increased vigor potentially from the effects of heterosis has occurred in selections derived from poly cross blocks that have parents from different populations (Yamakawa, 1998).

The most closely related group to the Americas is the Polynesian grouping, which is characterized by pre-European contact dispersal throughout Polynesia following an East to west migration, with the source population most likely originating from South America, likely Peru and Ecuador (Roullier et al., 2013). The East Asian populations of sweet Potato were introduced to the Philippines and Pacific nations that were formerly part of the Spanish East Indies by Spanish colonizers. From there, it then rapidly spread via trade throughout East and South East Asia. This geographic region has become the most significant population group in dispersion and cultivation (Iese et al., 2018). Various European groups spread plants descending from those originating in the Caribbean throughout their colonies (Roullier et al., 2013). There are still cultivars descended from populations cultivated by the Caribbean's indigenous population existing within a patchwork of introduced varieties (Mendoza et al., 2018). There are also hybrids between populations derived from these different geographic regions, particularly many East Asian cultivars descended from hybrids between Mexican and Caribbean populations, this may have occurred due to later introductions from different colonial powers (Roullier et al., 2013).

Rapid globalization, breeding programs, and market forces have blurred the ranges of domestic populations and led to a considerable hybridization of the species (Roullier et al., 2013). The Pacific sweet potato is facing challenges to the group's future. In recent years, traditional cultivars have mainly been replaced by introduced cultivars in commercial production (Tisdale and Clement, 2016).

1.4 History of Hawaiian Sweet Potatoes

Sweet Potato, known as u'ala in the Hawaiian language, has been an important staple crop throughout the islands' history being introduced to Hawai'i by the original Polynesian settlers (Ladefoged et al., 2005). A wide range of cultivation methods has been used throughout the Hawaiian archipelago to produce u'ala (Hartshorn et al., 2006). In drier areas, sweet Potato eclipsed taro in importance (Hartshorn et al., 2006). The adaptability and importance as a staple food have helped u'ala develop strong ceremonial and cultural significance to the indigenous people of Hawai'i (Hartshorn et al., 2006). Despite the loss of many traditional varieties, the importance of maintaining traditional sweet potato cultivars is evident in numerous families and cultural practitioners who have kept collections alive for generations. Immigrants from sweet Potato consuming regions in China, Japan, and the Philippines brought the varieties that are now commercially dominant in Hawai'i. These varieties include Okinawa, a purple flesh variety that has become the local standard in the state (Pulakkatu-thodi et al., 2018). These have largely replaced the traditional Hawaiian varieties. Many of the traditional varieties were lost, and many are currently in danger of being lost (Ladefoged, 2005). This follows a region-wide trend in the loss of genetic diversity in Pacific traditional crops (Tisdell and Clement, 2016). These losses are irreversible and may threaten regional food security.

1.5 Sweet Potato Production

Sweet potatoes are important to global food security. They are currently being used to address vitamin deficiencies and famine prone regions, especially in the face of climate change in vulnerable tropical and subtropical regions. This is also the seventh most crucial crop globally (Thiele et al., 2017). Asia is the largest producing region, with China being the largest producer

(**Figure 1.1**; Thiele et al., 2017). In the Pacific Region, the crop is rapidly growing again in importance as other traditional root crops decline at a faster rate. However, this expansion is not necessarily of traditional varieties and is mostly occurring in the Melanesian region, with the trend not continuing or not to the same extent in Polynesia (Iese et al., 2018). The crop can grow in a wide range of agricultural systems; soil types are drought tolerant and are adaptable for intercropping (Wolff et al., 1990). Hawai'i had a strong export industry in the 1990s focused around larger growers catering in niche markets of purple-fleshed roots for both fresh market and processing outside of Hawai'i (Valenzuela et al., 1994). However, the crop has declined in importance over the last two decades in the state, especially in the number of growers and the increasing importance of more extensive processing oriented operations over small and organic farmers who are being pushed outgrowing the crop (**Figure 1.2**).

1.6 Economic and Market Concerns Facing Sweet Potato Production in Hawai'i

Sweet potato farmers, especially small-scale producers, are facing many economic pressures in Hawai'i. This includes the state's isolation, high land costs, and the low value of fresh market material. Sweet potato production also requires large amounts of expensive labor or specialized machinery that is cost-prohibitive to many small growers and contributes to the shift to a smaller number of larger-scale dedicated growers (Valenzuela et al., 1994). Fresh market production for both local and export markets typically has a low return on investment. In response, larger growers have invested in converting the crop into value-added products such as chips. The equipment and licensing costs needed to turn the sweet Potato into value-added products are also a barrier to many small and organic growers, further restricting their ability to grow Sweet Potato

commercially. This difficult economic situation has caused an increasing number of small growers to grow other higher-value crops or leave agriculture altogether. Mainland and other region import competition have also weakened the economic situation for local Hawai'i growers.

1.7 Sweet Potato Breeding

Sweet potatoes are self-incompatible; thus, the most common breeding method is utilizing an open-pollinated poly cross block (Martin, 1985). This method has been used in Hawai'i's long and successful history of sweet potato breeding (Chung, 1923). In these breeding programs the main focus was often on agronomic performance with little intention of maintaining traditional germplasm. This led to indiscriminate crossing of traditional and introduced sweet potato lineages, complicating the descent of released cultivars as the use of these came to prominence and were used in further breeding work (Poole, 1952). The need to parse what plant material was traditional or traditional descent and other origin has encouraged other research to find the origins of these sweet potatoes (Winnicki et al, in review). It is through this interest and research that presumed traditionally descended cultivars were collected and the opportunity came to use them in a when a cultivar of former traditional use was pollinated in a polycross block.

Globally there is a multitude of programs focused on breeding sweet Potato for human consumption and industrial applications such as ethanol production (Yamakawa, 1998). Sweet Potato is also the subject of biofortification projects meant to address nutrient deficiencies through high Vitamin A (in the form of beta-carotene) content present in orange-fleshed cultivars (Mukherjee et al., 2002). In tropical regions, the majority of sweet potato varieties flower readily

making cross-pollination relatively easy. In temperate regions, long day-length inhibits regular flowering during the growing season, and so the use of rootstocks and other methods to force flowering is often employed (Okuno, 2005). A successful breeding program has been established in Tonga, which has been developing cultivars for local conditions using their traditional Polynesian population germplasm (Wilson et al., 1989). This project integrated the regional cropping styles in their selection to develop higher-yielding cultivars more suited to Tonga's traditional agricultural systems and local market preferences, both of which were not satisfactorily met with imported varieties.

1.8 The Rationale for Thesis Research

Hawaiian sweet potato populations appear to be genetically distinct relative to other cultivated populations (Winnicki et al., in review). Current Hawaiian heirloom types do not receive a price premium and do not yield comparably to commercial alternatives in modern cultivation systems (e.g., Okinawa), limiting commercial cultivation. However, the ability to verify genetics (Winicki et al., in review) coupled with selection for improved yield and potential for value-added products may increase the number of commercially grown heirloom types in the state. Similar studies on regional population genetics of sweet potatoes highlighted the value in utilizing distinct genetic populations to improve phenotypic qualities in commercial sweet potato populations (Wilson et al., 1989). Breeding work in Tonga has had promising results in utilizing the Tongan germplasm to breed for increased yield (Wilson et al., 1989). While traditional Tongan cultivars have been used, the breeding potential of the Hawai'i heirloom types has not been extensively explored. The traditional Hawaiian sweet potato population has not been

utilized alone in published breeding trials to this date and is, therefore, an untapped genetic resource.

A significant benefit of identifying potential cultivars with Hawaiian heritage is to increase the income of small and organic farmers, allowing more growers to stay in the sweet potato industry. While diversifying the range of cultivars available to growers is helpful, the goal is to provide growers a crop they can sell for a price premium without converting into a value-added product, similar to the price premiums received for heirloom vegetables (e.g., an increase of up to 400%, Dimitri et al., 2005) using the heirloom or traditional heritage of the plant. The identification of breeding lines comparable in traits to the current commercial standard Okinawa but can earn a price premium because of the cultivar's heritage would contribute to Hawai'i's food security and the viability of local agriculture.

Through openly using the traditional Hawaiian germplasm of sweet Potato in commercial cultivar development in collaboration with local indigenous-led organizations, this project hopes to encourage the development of demand centering around traditionally descended crop varieties so that the traditional varieties to once again become prominent in local food security. The relations with Waimanalo Pono Research Hui will contribute to the growing number of researchers at the University of Hawai'i that seek to foster community involvement to serve the people of Hawai'i in an appropriate way.

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1.12 Tables and Figures

Figure 1.1 *Global production of sweet potato (Ipomea batatas (L.) Lam) showing trends since the 1960's taken from publicly available data from the Food and Agriculture Organization of the United Nations. Production has risen and fallen re-stabilizing to around 100 million metric tonnes in the 2010's to the most recent available data available.*

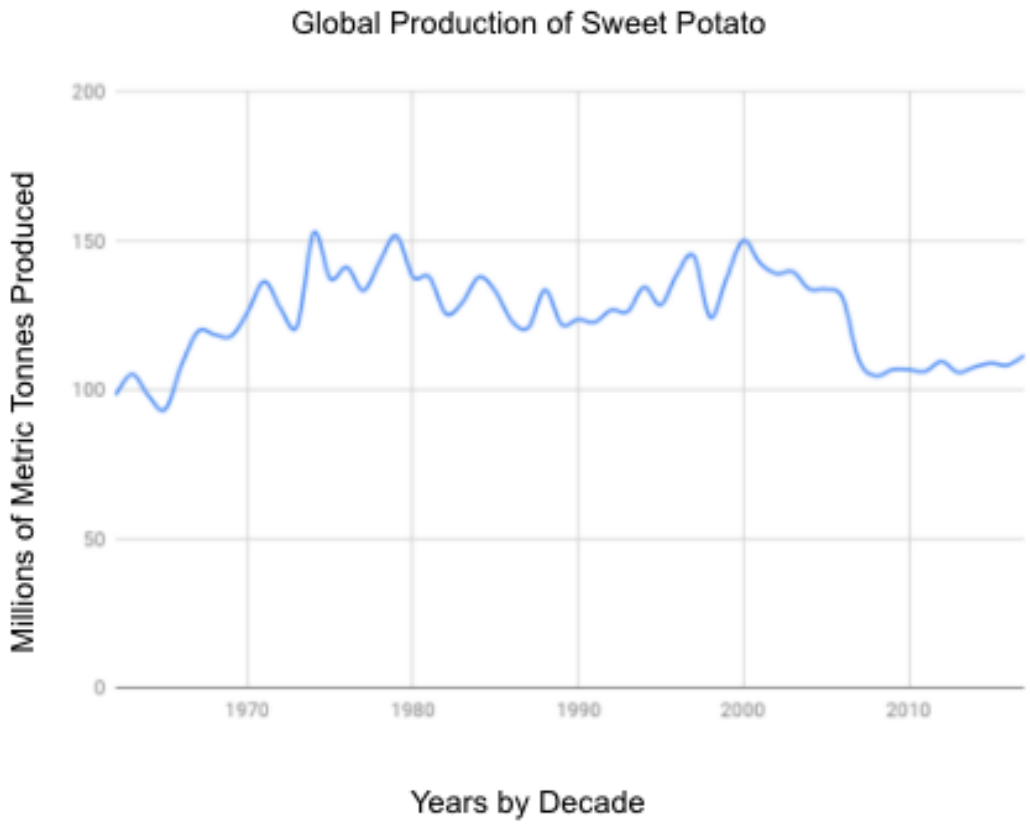

Figure 1.2 *Production of Sweet potato in Polynesia using data taken from publicly available data from the Food and Agriculture Organization of the United Nations. While data is not widely available on the amount of the harvest that is descended from Polynesian germplasm, there is a marked decline overall in production of sweet potato. The annual sweet potato harvests had dropped to less than half of the crop's 1970's peak.*

CHAPTER 2: EVALUATION OF BREEDING POPULATION FOR PHENOTYPIC TRAITS

2.1 Hypothesis

There are commercially viable breeding lines of sweet potato suited for Hawai'i commercial organic production within the twelve ‘Hawaiian heritage’ lines of sweet potato developed by the University.

2.2 Objectives

1. Identify relevant phenotypes that should be used to assess commercial potential in Hawai'i organic production.
2. Conduct field trials representative of organic sweet potato production in Hawai'i.
3. Using the phenotypes determined as commercially relevant, compare the breeding lines to the commercial standard cultivar, and three traditional Hawaiian cultivars including the maternal parent.
4. Determine breeding lines that have commercial potential or have unique characteristics.

2.3 Abstract

Sweet potato has a long history in Hawai'i, having been brought by the original Polynesian settlers. Traditionally named Hawaiian cultivars are currently used in niche markets but have been displaced due to import competition and better-producing cultivars derived from mainland sources. Here, new breeding lines derived from a crossing block of Hawaiian name cultivars resulted in twelve lines showing promising characteristics. To select identify if breeding lines widely adapted throughout Hawai'i and had commercial potential, twelve breeding lines were compared to one commercial check and three Hawaiian cultivar checks in three environments that differed in soil and climate. Different phenotypic traits such as fresh harvest yield, post-curing yield, and those describing shape and quality of the roots are essential for selecting breeding lines with commercial potential in Hawai'i. There were significant differences in yield between environments, mainly due to pest pressure. There were strong relationships between different yield components and between reduced yield and pest severity metrics. Based on a decision tree, two of two breeding lines, HM 26 and HM 34, are comparable to the commercial standard in terms of yield and sugar content; these breeding lines have commercial potential. Traditional Hawaiian germplasm has potential in as parents in modern breeding programs. This novel germplasm can produce lines with a comparable yield to the commercial standard in organic cultivation. While two lines show the improved yield, other breeding lines (e.g., HM 32) may also have potential in different niche markets or continued breeding because of their unique color characteristics that match Hawaiian preference.

2.4 Introduction

Sweet potato is an important crop around the world, and of particular interest to Hawai'i due to a long history of cultivation. Further, Native Hawaiians and smallholder farmers using organic production methods have an increased interest in growing sweet potato for both fresh and value-added markets (Krishnakumar et al., 2009). Sweet potato farmers in Hawai'i have many challenges, including being far from markets, high costs (personal, land, machinery), and low value for unprocessed yields. Fresh market production typically has had a low return on investment. In response, larger growers have moved to produce value-added products. While sweet potatoes are grown throughout the diverse microclimates of Hawai'i, most commercial sweet potato production in the state occurs in drier regions such as on Molokai (Valenzuela et al., 1994). However, industrial sweet potato production is growing on a commercial scale on wetter areas of the Big Island of Hawai'i.

The tremendous cultural value and precarious position state of the traditional Hawaiian sweet potato cultivars, many of which were lost in the 20th century, has increased the interest of using this unique material to breed new cultivars. The noted wide genetic diversity in the traditional Oceanic sweet potatoes and substantial community interest, thus the potential of this breeding population needed to be assessed (Zhang, 2004). In Tongan breeding work, lines descended from Polynesian descent germplasm had success in developing varieties tailored for their local agroecosystems (Wilson et al., 1989). While a mostly untapped genetic resource, traditional pacific cultivars often do not have the same yield as commercial cultivars yet may be essential in developing future climate-resistant crops (Champagne et al., 2009). The increase in local market

demand with the value-added aspect of the traditional Hawaiian descent may make up for this yield deficit (Glover, & Stone, 2018).

An additional way to increase value is to breed for production under organic systems, which has been shown to increase crop value for small growers (Dos Santos et al.,2019). It has been observed that on top of the heirloom price premium, additional price premiums of 9-100% could be expected for organically grown products (Dimitri and Oberholzer, 2005). The selection pressure in conventional growing conditions is often different than in organic systems, so the breeding lines considered successful might differ (Dos Santos et al., 2019).
Integrating grower and community input on the direction of breeding programs help to ensure the long-term adoption of the new varieties (Almenkinders and Elings, 2001). Community collaborations are meant to incorporate local needs more effectively into defining breeding objectives and markets. Integrating the self-perceived needs of growers and indigenous communities allows for more effective implementation, especially in resource-poor areas (Banziger and Cooper, 2001). Community participation in Hawai'i is primarily because of the cultural value of sweet potato germplasm (Kagawa et al., 2019) and the working partnerships that have been developed (Chung-do et al., 2019).

This study aims to assess the potential of 'Hawaiian Heritage' breeding lines, which are descended from traditional Hawaiian cultivars. To this end, yield metrics, root shape, damage susceptibility, color and sugar content were evaluated in twelve 'Hawaiian Heritage,' one commercial check, and three Hawaiian cultivars were evaluated in three environments.

2.5 Materials and Methods

Hawaiian Heritage materials were developed within a polycross block in 2016. This polycross block consisted of the Hawaiian pollen parents Hua Moa, Mohihi from Waimea Gardens, Ele' Ele, PA'APA'A, Lanai, Kahanu Purple, Pala'ai, Uala Kea, an unknown selection from Molokai and Ho'olehua, with the maternal parent being the Hawaiian cultivar Mohihi from Lyon arboretum. Initial evaluations of F1 seedlings were made based on visual inspection of root characteristics in Waimanalo, HI, in 2017. From these initial evaluations, 12 superior F1 plants were selected to be compared to four commercial checks (**Figure 2.1**). The commercial checks were Okinawa, chosen because it is the primary commercial cultivar in the state, Lanikeha selected because it is a traditional Hawaiian variety that has increasing interest for small scale homestead growers in Molokai according to local extension agents. And Kahanu Purple, after all, it is popular among homestead growers and in research on traditional agricultural systems on the Big Island; and a Mohihi, descended from the Lyon arboretum's collection because it is the maternal parent as well as historically used in brewing (a potential niche market). Two locations were selected to represent the principal areas of commercial sweet potato cultivation in Hawai'i. One that has the preferred low to moderate rainfall with oxisol soil (Poamoho, 21° 33' 42" N, 158° 4' 19" W), and a less suitable area with heavier soil and higher rainfall, (Waimanalo, (21° 20' 52" N, 157° 43' 16" W). The study was conducted in 2018 and 2019. The soil types were a Waimanalo series mollisol soil at Waimanalo and a Waialua series oxisol soil at Poamoho. The experimental design in 2018 was a randomized complete block with 12 treatments and three replications, and the experimental design in 2019 was a randomized entire block with 16 treatments and four replications. Planting dates were October 2018 and May 2019.

The plants were grown under organic management practices. Plant spacing, disease management, and fertilization follow the University of Hawai'i College of Tropical Agriculture and Human Resources extension guidelines (Valenzuela et al., 1994), with some modifications. Apart from modifying the extension guidelines to meet organic requirements, the standard recommendations were altered to be conducted at a small scale with minimal mechanization (Valenzuela et al., 1994). For example, instead of using machine cultivation as outlined in the recommendations for weed abatement, hand cultivation was employed until stand establishment, with 1.22-meter woven plastic weed mat being laid between rows after the fertilizer banding. Rows were 1.4 meters long, with 1.5 meters between rows. The blocks in the fall Waimanalo 2018 trial consisted of three blocks in six mounded beds 10 meters long. Four blocks consisted of eight beds in the spring Waimanalo planting, and beds were 16 m long to accommodate the check cultivars. The blocks at the Poamoho location had to be longer because of the topography of the available field. There were four blocks arranged in four beds that were 32 meters long. Coverage of weed mat allowed for only a 30 cm area exposed around the plants. The weed mat also rendered unnecessary the process of "turning the vines" done to prevent roots forming within rows, as plants do not generally root through weed mat. Harvest occurred for the first planting in March 2018. Harvest occurred in October 2019 for the May plantings in 2019. The sweet potatoes were cured in a curing chamber made from tarps set in the sunny area and sealed using clamps to maintain a temperature of 90 F° and 90% humidity (Valenzuela et al., 1994) for ten days to become market ready.

A total of ten phenotypes were measured 1) metric tonnes per hectare, 2) root numbers and 3) sugar content for uncured sweet potato were taken at harvest 4) shape, 5) weevil damage, 6) cracking, 7) rotting, 8) sprouting loss percentage, 9) yield post-curing 10) sugar content cured samples of sweet potato were taken after curing. Full phenotype methods can be seen in (**Table 2.1)**. These phenotypes were chosen based on historical traits that were used for both processing and fresh market breeding trails in Hawai'i (Poole, 1952). Data was analyzed as an augmented design to account for missing data between environments. A mixed model using rep within the year as a random effect and line as a fixed effect using the R package lme4 (Bates et al., 2018) and smartest (Kuznetsova et al., 2015). Least square means were calculated using the R package means (Lenth et al., 2018) and separated using an LSD. Each of the ten numeric phenotypes was compared to the performance of the commercial check of Okinawa and the traditional checks of Lanikeha, Mohihi from Lyon arboretum (referred to as Mohihi), and Purple Kahanu.

2.6 Results

Yield Components

Each environment was analyzed separately; in each environment, there were differences between 'Hawaiian Heritage' breeding lines for many traits (**Table 2.2).** In the Waimanalo 2018 yield (metric tonnes per hectare fresh weight), the only 'Hawaiian Heritage' breeding line with a higher yield than the commercial check Okinawa was HM 26 (**Figure 2.1; Table 2.2)**. However, three lines of HM 26, HM 35, and HM 46 performed better than Hawaiian check Lanikeha, but no line performed differently than the maternal parent Mohihi (sourced from the Lyon Arboretum). The

Waimanalo 2019 environment had similar results, with the only 'Hawaiian Heritage' breeding line performing better than commercial check Okinawa was HM 26. Compared to the Hawaiian cultivar check, the 'Hawaiian Heritage' lines HM 26, HM 46, and HM 34 outperformed Lanikeha with no line performed differently than the maternal parent Mohihi. In the 2019 Poamoho environment, the 'Hawaiian Heritage' HM 26 once again performing better than commercial check Okinawa, while the breeding lines HM 12, HM 16, HM 34 and HM 35 producing significantly more abundant fresh harvests compared to Lanikeha, and again no line performing differently than the maternal parent Mohihi.

For root number (**Table 2.3**), in the 2018 Waimanalo planting, the only 'Hawaiian Heritage' breeding line that differed from both the commercial check Okinawa, and the traditional Hawaiian material Lanikeha, and the maternal parent Mohihi was HM 3. However, HM 3 did not differ in root number from Purple Kahanu. This trend of HM 3 being different held for the Waimanalo 2019 planting as well as the Poamoho 2019 planting. In the Waimanalo 2019, there HM 3 was also the only breeding line that differed from Lanikeha, Mohihi, and Okinawa, while it was not different than Purple Kahanu. At the Poamoho 2019 planting, the same pattern continued with HM 3 again being the only breeding line separate from Okinawa, Lanikeha, or Mohihi. Still, again, it was not different from Purple Kahanu's number of roots per plot.

The post-curing yield differences to the checks were not consistent over the environments (**Table 2.4)**. In Waimanalo 2018, lines HM 3 and HM 26 were different than the commercial check Okinawa. Lines HM 12, HM 16, HM 26, HM 35, and HM 46 were different than the Hawaiian cultivar Lanikeha. No lines were different from Mohihi, the maternal parent, and the

Hawaiian cultivar Purple Kahanu. Waimanalo 2019 had many more lines different than Okinawa, with HM 12, HM 16, HM 17, HM 18, HM 26, HM 3 being different. Lines HM12, HM 16, HM 17, HM 18, HM 26, HM 3, HM 32, HM34, and HM 35 were different than Purple Kahanu. No lines from the Waimanalo 2019 were different than Mohihi or Lanikeha. For the Poamoho 2019 planting, Lines HM 12, HM 16, HM 26, HM 34, HM 35, and HM 46 were different than Lanikeha. Line HM 26 was different from Okinawa, and Purple Kahanu as well. No lines were different than the maternal parent Mohihi in the Poamoho 2019 planting.

Quality Traits

For shape (**Table 2.5)** in Waimanalo 2018, Line HM 32 was different than Purple Kahanu, and no other lines were different from the commercial check Okinawa, the Hawaiian cultivars Lanikeha or the maternal parent and Hawaiian cultivar Mohihi. In Poamoho 2019, Line 32 was different from Mohihi in shape; no other line was different. No Line was different from the commercial check Okinawa. No line was different than the Hawaiian cultivar Lanikeha or the maternal parent Mohihi.

For the sucrose percentage in the uncured roots (**Table 2.6)**, there were no significant differences between the breeding lines of the commercial check or the Hawaiian cultivars in any of the three plantings. There was no significant difference between any of the breeding lines at the Waimanalo 2018 planting compared to the commercial check Okinawa. There was no difference with the breeding lines compared to the Hawaiian cultivars Lanikeha or Purple Kahanu and the maternal parent Mohihi. The same outcome was observed in the Waimanalo

2019 planting with no lines showing a difference for the commercial check Okinawa or the Hawaiian cultivars of Lanikeha, Purple Kahanu, or the maternal parent Mohihi. The Poamoho 2019 planting had similar results with none of the breeding lines having sucrose concentrations different than Okinawa or the Hawaiian cultivars Lanikeha, Purple Kahanu, or the maternal parent Mohihi.

There was also no significant difference in the sucrose percentage compared to the check cultivars in the cured roots in the three plantings **(Table 2.7)**. In the Waimanalo 2018 planting, there was no significant difference with any of the breeding lines compared to the commercial check Okinawa, the Hawaiian check cultivars Lanikeha or Purple Kahanu or the maternal parent Mohihi. The Waimanalo 2019 planting had a similar outcome, with there being no statistically significant difference between any of the breeding lines when compared to the checks such as Okinawa, the Hawaiian cultivars of Lanikeha, Purple Kahanu or the maternal parent Mohihi. Poamoho 2019 also had a similar outcome of none of the breeding lines, havening a statistically significant difference to any of the checks of the Okinawa, Lanikeha, Purple Kahanu or the maternal parent Mohihi.

The percentage rotting during curing (**Table 2.8)** did not vary between breeding lines and check cultivars. The Waimanalo 2018 planting showed no difference between breeding lines when compared to Okinawa. There were also no differences between the Hawaiian check cultivars of Purple Kahanu and Lanikeha or the maternal parent Mohihi. The Waimanalo 2019 planting had a similar outcome with no difference between the breeding lines and the check cultivars of Okinawa, Lanikeha, Purple Kahanu, or Mohihi. The Poamoho 2019 planting also had no

significant difference between the breeding lines and the check cultivars of Okinawa, Lanikeha, Purple Kahanu, or Mohihi. Sprouting loss **(Table 2.9)** also had no significant difference across the different growing time and location combinations. The Waimanalo 2018 planting showed no difference between the breeding lines and the commercial or Hawaiian checks. Waimanalo 2019 also had the same outcome with no breeding line being different than any of the check cultivars of Okinawa, Lanikeha, Purple Kahanu, or Mohihi. Poamoho 2019 had no differences in any lines.

Weevil damage (**Table 2.10)**, similar to the sprouting and rotting losses in that there were no differences. The Waimanalo 2018 planting had no difference between the breeding lines and the commercial check Okinawa, or the other checks the Hawaiian cultivars Lanikeha, Kahanu Purple, or the maternal parent Mohihi. Waimanalo 2019 also had the same outcome with no breeding line being different than any of the check cultivars of Okinawa, Lanikeha, Purple Kahanu, or Mohihi. However, Waimanalo 2019 was different from the other two plantings in being entirely decimated by sweet potato weevil; all the lines were decimated equally. Poamoho 2019 had no breeding line different than any of the check cultivars of Okinawa, Lanikeha, Purple Kahanu, or Mohihi.

The cracking damage percentage was also low for **(Table 2.11)** Waimanalo 2018 planting had no significant difference between the breeding lines and the commercial check Okinawa, or the other checks the Hawaiian cultivars Lanikeha, Kahanu Purple or the maternal parent Mohihi. Waimanalo 2019 also had the same outcome with no breeding line being different than any of the check cultivars of Okinawa, Lanikeha, Purple Kahanu, or Mohihi. Poamoho 2019 had no

breeding line that was different from any of the check cultivars of Okinawa, Lanikeha, Purple Kahanu, or Mohihi. In Poamoho 2019, Despite the lines HM 3, HM 32, HM 34, HM 35, HM 39, HM 4, and HM 46 having zero reported cracking, there were still no differences between the lines.

Trait Relationships

The phenotypes of damage such as percentages related to root damage such as percentages of roots affected by cracking, weevil damage, and sprouting **(Figure 2.3)** were positively correlated to rotting phenotype after curing (**Figure 2.4**). The physiological damage or processes within the root make the sweet potato less likely to survive curing. For instance, cracking damage causes ruptures in the dermis of the sweet potato, exposing the starch-filled cortex to pathogens in the soil, wound healing would not be able to occur during curing with these damages (Atuna, 2017). Cracking can be caused by sudden fluctuations in soil moisture and genetic factors, which is why the phenotype was explored to see if there were any differences between lines. This information could be used to streamline the number of phenotypes in more extensive trials with the Hawaiian descended breeding population.

The sweet potato weevil larvae burrow into the root, introducing secondary pathogens and leaving chaff that can decompose inside the root and encourage rotting of the root themselves. This reduces the ability to store the roots and makes them unsalable for fresh market (Pulakkatu-thodi, 2018). The Waimanalo 2019 planting had an infestation of sweet potato weevil, with an almost total infestation in all roots. The total loss of rotting during the curing was most likely

directly caused by the weevil damage, as suggested by the correlations of this phenotype and the rotting that was seen in this planting **(Figure 2.4)**. Rotting could be used as a proxy for weevil damage in future trials.

The sprouting loss is also correlated with percent loss rotting. Roots that sprout during curing **(Figure 2.3)** cannot be sold. This is an important metric when looking at the potential curability and storability of breeding lines. This could potentially lower quality and reduce the stored energy the root needs for respiration, lowering the yield potential. The phenotypes of shape, measured with length by width, root number, the fresh harvest yield, and cured and uncured sucrose percentages, were not related to yield reduction. (**Figure 2.4**). There were no phenotypes that strongly affected fresh harvest yield.

2.7 Discussion

There are two distinct markets for the 'Hawaiian Heritage' breeding material, fresh market, and processing market (e.g., brewing). A decision tree was made (**Figure 2.2)** using the phenotypes that were explored to select breeding lines for the different potential markets. While using the decision tree, phenotypic differences are relative to both the commercial check Okinawa and the Hawaiian cultivar checks to make practical comparisons of performance in organic cultivation. First, the selection of the processing cultivars will be addressed; the only important trait related to processing for brewing potential is fresh yield. Unlike for fresh market, appearance and consumer opinion will not impact adoption (Yamakawa, 1998). Therefore, the decision tree starts with the comparison of fresh harvest yield (**Table 2.2)**. This trait is considered, there is a

definite top performer, which was the best performing line in all environments; this is the 'Hawaiian Heritage' breeding line HM 26. For both the markets, the 'Hawaiian Heritage' breeding line HM 26 is the most promising candidate. HM 26 performed better than the commercial standard Okinawa in fresh harvest weight and was the highest yielding line in all environments. For this reason, HM 26 would be going forward to be considered for the next selection. Also, the 'Hawaiian Heritage' breeding lines HM 26, HM 34, HM 46, HM 12, HM 16, HM 35 yielded more than traditional Hawaiian lines and had yields comparable to Okinawa but statistically better than Lanikeha so they could not be eliminated in the first stage of the decision tree. These breeding lines may have the potential for processing for uses, such as brewing on the merit of their fresh yield from the field alone.

The second part of the selection process looks at the potential of the 'Hawaiian Heritage' breeding lines to be fresh market sweet potato cultivars. When exploring fresh market potential, some traits are as important as yield. The first trait of importance after yield is sucrose content; this trait is not essential for brewing as material for brewing undergoes enzymatic digestion. A high sucrose content improves taste and improves fresh market value (Dos Santos et al., 2019). In Hawai'i, uncured sugar content is vital as this is not the standard practice; however, for the rest of the country, the cured sugar content will be more critical. Among the 'Hawaiian Heritage' breeding lines that showed yield higher than traditional Hawaiian varieties (HM 26, HM 34, HM 46, HM 12, HM 16, HM 35), the one with the highest sucrose content was HM 18 both cured and uncured samples. However, there were no significant differences between the different cured and uncured percent soluble sucrose content, so all breeding lines continued to the next selection factor. There was difference in the percent sucrose content across the different environments,

Poamoho having the highest soluble sucrose contents. This may in part be caused by the location having a higher solar radiation exposure because of the drier and sunnier climate compared to Waimanalo. Higher solar radiation exposures in sweet potato fields being correlated with higher dry matter, including sugars, in sweet potatoes (Agata and Taketa, 1982).

The curing practice also brings in a new yield metric that must be addressed in the selection process, this is assigned as the post curing yield. This metric is the amount of yield loss that occurred during the curing process. This value is important for the potential fresh market for export and storage potential, of which curing is a national industry standard (Picha, 1987). This is a problematic metric to score as it can be related to other factors, including insect damage and shape (Atuna et al., 2017). Sweet Potato weevil, a common pest among local sweet potato growers, damaged the roots so that post-curing measurements could not be taken at the Waimanalo 2018 planting. While the vegetative growth did not appear dramatically different, the quality of the roots would make this planting effectively a crop failure. This issue is not uncommon in Hawai'i sweet potato production, especially in an area that is not preferred for commercial sweet potato production with high rainfall and heavy soil with a recent history of sweet potato cultivation (Pulakkatu-thodi et al., 2018). There was wide variation in the breeding lines in post-curing harvest yield. However, the best lines were HM 26, HM 3, and HM 34.
The final level of the selection process is addressing shape and color. When evaluating shape, identifying what is good is slightly different. In this case, the goal is to have 'Hawaiian Heritage' lines have a shape that is the same as the commercial check Okinawa. The length by width metric is a proxy for the shape of the sweet potato; it displays the blocky or lengthy forms the roots of the different breeding lines and check plants produce. To conform to current market

expectations, and to ensure that existing processing machinery would not need modifications for any of the new breeding lines. None of the breeding lines were significantly different in length and width from Okinawa **(Table 2.5)**. The color was an important consideration because of intense local market demands and preferences for purple flesh in the fresh market. For this reason, while not performing yield wise superior to HM 26, the purple flesh breeding line HM 34 may be a better candidate for fresh market targeted production.

These sequential steps outlined in **(Figure 2.2),** provide a clear pathway for bringing 'Hawaiian Heritage' breeding lines to market. The Breeding line HM 34 and HM 26 had higher curing harvest yield, and so may be considered for the fresh market and processing since they were similar to Okinawa in length in shape. These two lines are excellent candidates for further study. The unique appearance of some other breeding lines, such as HM 32, may also be of interest purely because of its uniform purple flesh and skin.

Building relationships with community organizations

There is great value in building relationships and collaborations with local and indigenous communities in research (Chung-Do et al., 2019), especially in Hawai'i (Kagawa et al., 2019). Community collaboration improves relations and trust with a research institution (Chung-Do et al., 2019). Strong ties with indigenous and local communities can foster local youth's participation, potentially increasing their future representation with the university and the department. This would benefit the community by increasing local opportunities while supporting the university and research (Keaulana, 2019). The Waimanalo Pono Research Hui, a Hawaiian non-profit based in Waimanalo, works to normalize research protocols enabling

greater involvement and impact for both the University of Hawai'i and local organizations throughout the state (Chung-Do et al., 2019). This is important, especially for the University of Hawai'i at Manoa's plant breeding focused research because of historically poor relationships between University plant breeders and local communities (Keaulana, 2019). Ensuring that research is done in collaboration with indigenous-led local organizations is essential for the sustainability of morally grounded research at the University of Hawai'i.

2.8 Conclusion

There are potentially useful traits in the 'Hawaiian Heritage' breeding populations. Of the lines evaluated, HM 34 and HM 26 have the most potential for fresh market production. HM 26 also has the potential for processing. The 'Hawaiian Heritage' breeding lines HM 34 and HM 26 suitability will need further screening in more extensive production scale trials in the target environments to see if growers will adopt them. HM, 26 is white-fleshed, and local preferences have a strong bias to purple flesh varieties (Pulakkatu-thodi, 2016). HM, 34 may be a better candidate despite HM 26 having the ability to have higher yields, due to its better fitting local flesh color preference. With the full color variations in the breeding lines **(Fig 2.1)**, as too other breeding lines that did not make the selection parameters, could be used in further breeding work to utilize their coloration or may have other markets and uses, such as with hobbyists and backyard growers. They may also have potential in future breeding work with this population because of the unique colors displayed in HM 32, HM 39, and HM 16. Further work should be done to broaden the awareness of traditional Hawaiian cultivars of sweet potato. This would ensure there is widespread local awareness before these cultivars reach the market. Marketing

could also be done, so local families see the value in cultivars of sweet potato descended from traditional Hawaiian cultivars. The hopeful outcome is new cultivars descended from the traditional Hawaiian sweet potato can be used to address issues affecting small and organic sweet potato growers.

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2.10 Tables and figures

Table 2.1 Table explaining the methodology for evaluating the phenotypes of interest for breeding ʻHawaiian Heritage' breeding lines.

Fresh yield metric tonnes per hectare	Total fresh weight of washed tubers from each breeding line in and plot. Using the size of the plots and the yield in kilograms, the yield per hectare was calculated.
Root number per plot	Total number of roots for each genotype was counted for all of the plots in every block.
Post curing yield metric tonnes per hectare	The percentage of total tubers that must be discarded because of rot after the curing process.
Shape	A subset of ten roots for each breeding line and replication was measured at the widest point, with the same roots being measured at the longest point.
Uncured sucrose	Tissue samples were taken from singular roots from each breeding line and replication combination. Tissue was taken in approximately 1.3 cm thick slices without the epidermis from the center of the roots. This tissue was then steamed over boiling water in plastic bags until cooked for approximately 15 minutes, then freeze dried, powdered and mixed in a solution of distilled water and ethanol. This was centrifuged four times to remove solids and leaving only the solution. The solution was processed using high performance liquid chromatography (HPLC) in a Waters 2965 machine using acetonitrile (CH3CN) as the solvent. Soluble sucrose was determined using the area under the curve compared to a commercial sugar standard from Fisher Scientific using the software Empower 3. HPLC output from each sample was compared to the commercial sucrose standard from a Supelco Analytical 47267 Monosaccharides kit to determine percentage of sucrose per sample.

Cured sucrose	Tissue samples were taken from a single representative root from each breeding line from each. Tissue was taken in approximately 1.3 cm slices without the epidermis from the center of the roots. This tissue was then steamed over boiling water in plastic bags until cooked for approximately 15 minutes, freeze dried, powdered and mixed in a solution of distilled water and ethanol. This was centrifuged five times to remove solids and leaving only the solution. The boiling procedure was added to more thoroughly extract sugars in a state that consumers would cook the roots. The extra centrifuging was because the curing process changed the properties of the tissue and the machine was more prone to clogging. Using acetonitrile (CH3CN) as the solvent, HPLC output from each sample was compared to the commercial sucrose standard from a Supelco Analytical 4767 Monosaccharides Kit to determine percentage of sucrose per sample.
Rotting	The percentage of roots that must be discarded because of rot during the curing process.
Sprouting loss percent	The percentage of roots that must be discarded because of sprouting during the curing process.
Weevil	Visual inspection of roots that cannot be sold fresh market due to damage. This was classified as any form of weevil damage. This was done as a percentage of roots that showed the damage.
Cracking damage	Visual inspection of roots that cannot be sold fresh market due to damage. The percentage of roots damaged by cracking during curing.

Table 2.2 Least Square Means for fresh yield (Metric tonnes per hectare), model adjusted means that were lower than 0 or greater than 100% were changed to these values to represent biological reality.

Breeding Line	Fresh Yield Metric tonnes per Hectare					
	Waimanalo 2018		Waimanalo 2019		Poamoho 2019	
HM12	32.8†	abc	9.6†	abc	26.0†	abc
HM16	35.4†	ab	12.2†	ab	28.7†	ab
HM17	13.6	e	0	e	6.8	e
HM18	28.9	abcd	5.7	abcd	22.1	abcd
HM26	39.9*†	a	16.7*†	a	33.2*†	a
HM3	28.3	abcd	5.2	abcd	21.6	abcd
HM32	27.7	abcd	4.6	abcd	21.0	abcd
HM34	31.7†	abc	8.5†	abc	25.0†	abc
HM35	36.0†	ab	12.9†	ab	29.3	ab
HM39	26.3	bcde	3.1	bcde	19.6	bcde
HM4	21.7	cde	0	cde	15.0	cde
HM46	31.0†	abc	7.8†	abc	24.3	abc
Lanikeha	15.53	de	0	de	8.8	de
Mohihi Ly	28.0	abcde	4.8	abcde	21.2	abcde
Okinawa	21.6	bcde	0	bcde	14.9	bcde
Purple Kahanu	26.1	abcde	3.0	abcde	19.4	abcde

* Different from Okinawa
† Different from Lanikeha
‡ Different from Purple Kahanu
** Different from Mohihi (from Lyon arboretum)

Table 2.3 Least Square Means for root number per plot, model adjusted means that were lower than 0 or greater than 100% were changed to these values to represent biological reality.

Root Number Per Plot

Breeding Line	Waimanalo 2018		Waimanalo 2019		Poamoho 2019	
HM12	33.1	abc	23.7	abc	22.9	abc
HM16	34.9	abc	25.5	abc	24.7	abc
HM17	15.6	c	6.3	c	5.4	c
HM18	31.9	abc	22.5	abc	21.7	abc
HM26	29.2	abc	19.9	abc	19.0	abc
HM3	50.5*†**	a	41.2*†**	a	40.3*†**	a
HM32	41.0	ab	31.6	ab	30.8	ab
HM34	37.0	abc	27.6	abc	26.8	abc
HM35	35.1	abc	25.7	abc	24.9	abc
HM39	40.0	abc	30.6	abc	29.8	abc
HM4	27.1	abc	17.7	abc	16.9	abc
HM46	26.7	abc	17.3	abc	16.5	abc
Lanikeha	15.1	bc	5.8	bc	4.9	bc
Mohihi Ly	20.1	bc	10.7	bc	9.9	bc
Okinawa	20.7	bc	11.4	bc	10.5	bc
Purple Kahanu	28.5	abc	19.1	abc	18.3	abc

* Different from Okinawa
† Different from Lanikeha
‡ Different from Purple Kahanu
** Different from Mohihi (from Lyon arboretum)

Table 2.4 Least Square Means for results post curing (yield metric tonnes per hectare), model adjusted means that were lower than 0 or greater than 100% were changed to these values to represent biological reality.

Post Curing Yield Metric tonnes per Hectare

Breeding Line	Waimanalo 2018		Waimanalo 2019		Poamoho 2019	
HM12	28.7†	ab	9.0†*‡	a	26.1†	ab
HM16	29.5†	ab	9.8*‡	ab	26.8†	ab
HM17	10.8	d	0*‡	ab	8.1	d
HM18	24.2	abc	4.5*‡	ab	21.6	abc
HM26	36.0*†‡	a	16.3*‡	ab	33.4*†‡	a
HM3	24.1	abc	4.4*‡	ab	21.5	abc
HM32	24.2	abc	4.5‡	abc	21.6	abc
HM34	27.5†	ab	7.8‡	abc	24.8†	ab
HM35	30.8†	ab	11.1‡	abc	28.2†	ab
HM39	22.9	bcd	3.2	abcd	20.3	bcd
HM4	18.5	bcd	0	bcd	15.8	bcd
HM46	25.8†	ab	6.1	bcd	23.2†	ab
Lanikeha	11.7	cd	0	bcd	9.1	cd
Mohihi Ly	23.8	abcd	4.1	bcd	21.1	abcd
Okinawa	17.7	bcd	0	cd	15.1	bcd
Purple Kahanu	22.1	bcd	2.4	d	19.5	bcd

* Different from Okinawa
† Different from Lanikeha
‡ Different from Purple Kahanu
** Different from Mohihi (from Lyon arboretum)

Table 2.5 Least Square Means for shape, model adjusted means that were lower than 0 or greater than 100% were changed to these values to represent biological reality.

Shape Width by Length (cm2)

Breeding Line	Waimanalo 2018		Waimanalo 2019		Poamoho 2019	
HM12	2.5	bc	NA	NA	2.2	bc
HM16	2.5	bc	NA	NA	2.1	bc
HM17	3.6	ab	NA	NA	3.2	ab
HM18	2.6	abc	NA	NA	2.3	abc
HM26	2.4	bc	NA	NA	2.1	bc
HM3	2.6	bc	NA	NA	2.3	bc
HM32	3.8‡	a	NA	NA	3.5**	a
HM34	3.5	ab	NA	NA	3.1	ab
HM35	2.2	c	NA	NA	1.8	c
HM39	3.2	abc	NA	NA	2.9	abc
HM4	2.9	abc	NA	NA	2.5	abc
HM46	2.26	c	NA	NA	1.9	c
Lanikeha	3.6	abc	NA	NA	3.3	abc
Mohihi Ly	2.6	abc	NA	NA	2.3	abc
Okinawa	2.7	abc	NA	NA	2.4	abc
Purple Kahanu	2.3	bc	NA	NA	2.0	bc

* Different from Okinawa
† Different from Lanikeha
‡ Different from Purple Kahanu
** Different from Mohihi (from Lyon arboretum)

Table 2.6 Least Square Means for uncured sucrose (percent dry weight), model adjusted means that were lower than 0 or greater than 100% were changed to these values to represent biological reality.

	Uncured Sucrose (%)					
Breeding Line	Waimanalo 2018		Waimanalo 2019		Poamoho 2019	
HM12	5.6	a	6.5	a	9.5	a
HM16	8.4	a	9.4	a	12.4	a
HM17	5.3	a	6.2	a	9.2	a
HM18	8.9	a	9.8	a	12.9	a
HM26	5.1	a	6.1	a	9.1	a
HM3	5.2	a	6.1	a	9.1	a
HM32	7.2	a	8.2	a	11.2	a
HM34	5.0	a	6.0	a	9.0	a
HM35	5.2	a	6.1	a	9.1	a
HM39	6.2	a	7.1	a	10.1	a
HM4	7.9	a	8.8	a	11.8	a
HM46	7.3	a	8.2	a	11.3	a
Lanikeha	3.3	a	4.2	a	7.2	a
Mohihi Ly	4.7	a	5.7	a	8.7	a
Okinawa	5.5	a	6.4	a	9.5	a
Purple Kahanu	11.1	a	12.0	a	15.0	a

* Different from Okinawa
† Different from Lanikeha
‡ Different from Purple Kahanu
** Different from Mohihi (from Lyon arboretum)

Table 2.7 Least Square Means for cured sucrose (percent dry weight), model adjusted means that were lower than 0 or greater than 100% were changed to these values to represent biological reality.

	Cured Sucrose (%)					
Breeding Line	Waimanalo 2018		Waimanalo 2019		Poamoho 2019	
HM12	2.2	a	NA	NA	6.2	a
HM16	4.5	a	NA	NA	8.5	a
HM17	2.3	a	NA	NA	6.3	a
HM18	8.1	a	NA	NA	12.4	a
HM26	5.4	a	NA	NA	9.4	a
HM3	4.4	a	NA	NA	8.4	a
HM32	4.7	a	NA	NA	8.7	a
HM34	5.2	a	NA	NA	9.1	a
HM35	4.4	a	NA	NA	8.4	a
HM39	1.5	a	NA	NA	5.5	a
HM4	3.5	a	NA	NA	7.5	a
HM46	3.9	a	NA	NA	7.9	a
Lanikeha	NA	a	NA	NA	NA	a
Mohihi Ly	7.2	a	NA	NA	11.2	a
Okinawa	7.4	a	NA	NA	11.4	a
Purple Kahanu	6.6	a	NA	NA	10.7	a

* Different from Okinawa
† Different from Lanikeha
‡ Different from Purple Kahanu
** Different from Mohihi (from Lyon arboretum)

Table 2.8 Least Square Means for rotting (percent dry weight), model adjusted means that were lower than 0 or greater than 100% were changed to these values to represent biological reality.

	Rotting (%)					
Breeding Line	Waimanalo 2018		Waimanalo 2019		Poamoho 2019	
HM12	41.0	a	100	a	19.5	a
HM16	38.5	a	100	a	17.0	a
HM17	36.1	a	100	a	14.6	a
HM18	35.2	a	100	a	13.7	a
HM26	34.7	a	100	a	13.2	a
HM3	34.4	a	100	a	12.9	a
HM32	33.7	a	100	a	12.2	a
HM34	32.7	a	100	a	11.1	a
HM35	30.3	a	99.3	a	8.8	a
HM39	28.3	a	97.4	a	6.8	a
HM4	27.1	a	96.1	a	5.6	a
HM46	26.2	a	95.2	a	4.7	a
Lanikeha	25.6	a	94.6	a	4.1	a
Mohihi Ly	24.9	a	93.9	a	3.4	a
Okinawa	23.3	a	92.4	a	1.8	a
Purple Kahanu	22.9	a	91.9	a	1.4	a

* Different from Okinawa
† Different from Lanikeha
‡ Different from Purple Kahanu
** Different from Mohihi (from Lyon arboretum)

Table 2.9 Least Square Means for sprouting loss (percent), model adjusted means that were lower than 0 or greater than 100% were changed to these values to represent biological reality.

	Sprouting Loss (%)					
Breeding Line	Waimanalo 2018		Waimanalo 2019		Poamoho 2019	
HM12	4.57	b	NA	NA	0.3	b
HM16	8.11	ab	NA	NA	3.9	ab
HM17	12.44	ab	NA	NA	8.2	ab
HM18	6.29	b	NA	NA	2.1	b
HM26	22.97	ab	NA	NA	18.7	ab
HM3	11.51	ab	NA	NA	7.3	ab
HM32	11.44	ab	NA	NA	7.206	ab
HM34	10.02	ab	NA	NA	5.794	ab
HM35	29.41	a	NA	NA	25.182	a
HM39	6.25	b	NA	NA	2.021	b
HM4	4.38	b	NA	NA	0.149	b
HM46	4.09	b	NA	NA	0.000	b
Lanikeha	4.23	ab	NA	NA	0.000	ab
Mohihi Ly	4.28	ab	NA	NA	0.051	ab
Okinawa	11.42	ab	NA	NA	7.190	ab
Purple Kahanu	8.83	ab	NA	NA	4.596	ab

* Different from Okinawa
† Different from Lanikeha
‡ Different from Purple Kahanu
** Different from Mohihi (from Lyon arboretum)

Table 2.10 Least Square Means for weevil damage (percent), model adjusted means that were lower than 0 or greater than 100% were changed to these values to represent biological reality.

	Weevil Damage (%)					
Breeding Line	Waimanalo 2018		Waimanalo 2019		Poamoho 2019	
HM12	24.642	a	100	a	5.132	a
HM16	21.442	a	98.393	a	1.933	a
HM17	16.278	a	93.228	a	0	a
HM18	21.63	a	98.581	a	2.121	a
HM26	20.852	a	97.802	a	1.342	a
HM3	20.367	a	97.318	a	0.858	a
HM32	19.856	a	96.806	a	0.346	a
HM34	31.358	a	100	a	11.848	a
HM35	23.54	a	100	a	4.03	a
HM39	22.185	a	99.136	a	2.676	a
HM4	25.094	a	100	a	5.585	a
HM46	24.472	a	100	a	4.963	a
Lanikeha	25.405	a	100	a	5.895	a
Mohihi Ly	21.28	a	98.23	a	1.77	a
Okinawa	24.155	a	100	a	4.645	a
Purple Kahanu	26.238	a	100	a	6.729	a

* Different from Okinawa
† Different from Lanikeha
‡ Different from Purple Kahanu
** Different from Mohihi (from Lyon arboretum)

Table 2.11 Least Square Means for cracking damage (percent), model adjusted means that were lower than 0 or greater than 100% were changed to these values to represent biological reality.

	Cracking Damage (%)					
Breeding Line	Waimanalo 2018		Waimanalo 2019		Poamoho 2019	
HM12	3.9	a	3.9	a	9.0	a
HM16	5.6	a	5.6	a	2.8	a
HM17	4.2	a	4.2	a	1.7	a
HM18	7.9	a	7.9	a	1.0	a
HM26	15.9	a	15.9	a	0.7	a
HM3	6.8	a	6.8	a	0	a
HM32	4.6	a	4.6	a	0	a
HM34	5.6	a	5.6	a	0	a
HM35	9.8	a	9.8	a	0	a
HM39	6.5	a	6.5	a	0	a
HM4	5.3	a	5.2	a	0	a
HM46	7.6	a	7.62	a	0	a
Lanikeha	6.9	a	6.9	a	0	a
Mohihi Ly	6.9	a	6.9	a	0	a
Okinawa	6.9	a	6.9	a	0	a
Purple Kahanu	8.6	a	8.6	a	0	a

* Different from Okinawa
† Different from Lanikeha
‡ Different from Purple Kahanu
** Different from Mohihi (from Lyon arboretum)

Figure 2.1 'Hawaiian Heritage' breeding lines and check cultivars evaluating during this project. Okinawa is the commercial standard in Hawai'i, while Mohihi from Lyon arboretum is the maternal parent, Purple Kahanu and Lanikeha are traditional Hawaiian varieties. P K is "Purple Kahanu".

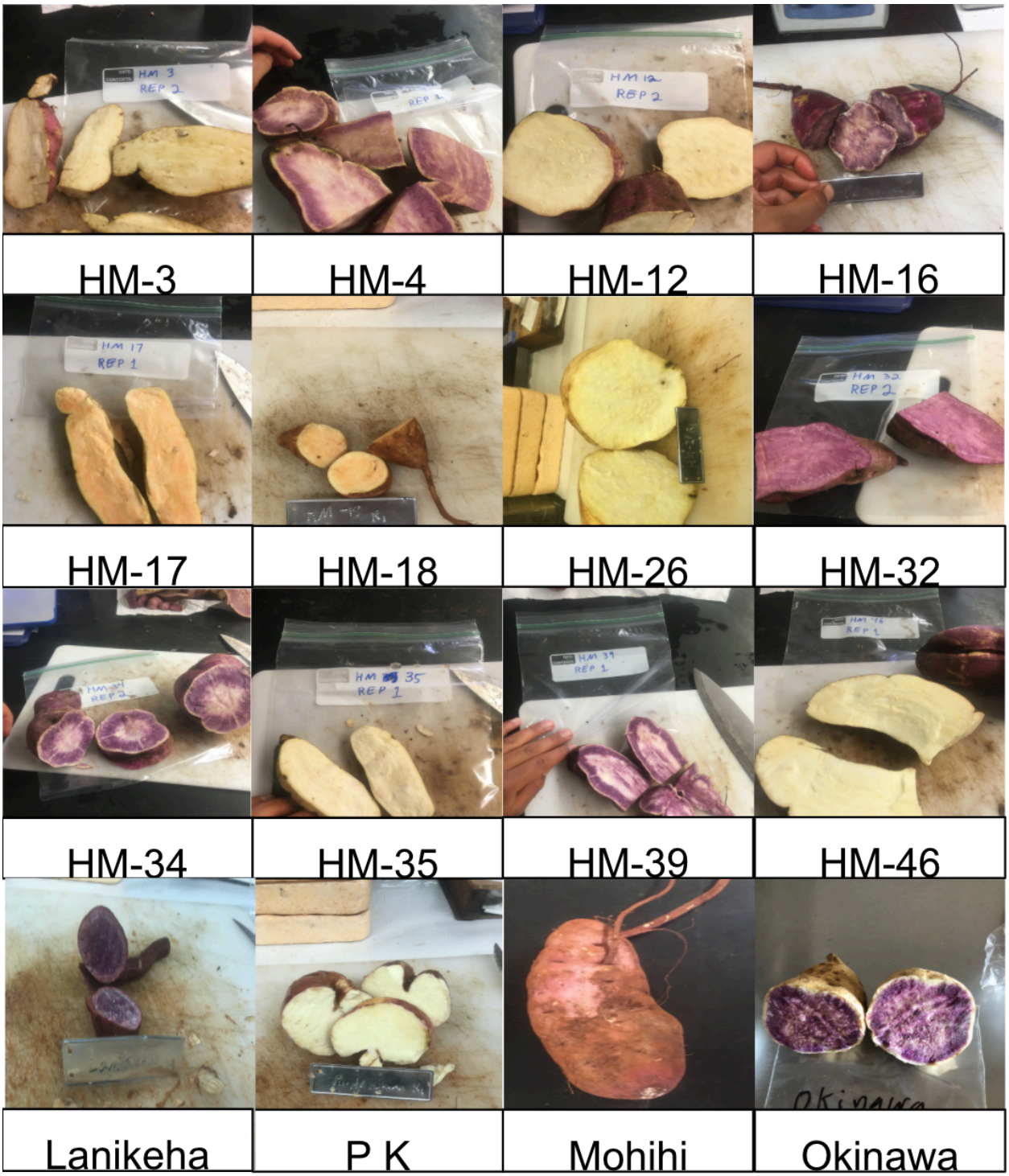


Figure 2.2 Selection roadmap for 'Hawaiian Heritage' sweet potato. There are two primary selection targets are for fresh market (or unprocessed) and for processing (Brewing lines). Each selection trait is compared to commercial standard Okinawa and Hawaiian name cultivars to be advanced. There are two entry points within this selection scheme at Tier 1, the first is before curing as this is not a common practice in Hawai'i and the second is after curing which is the industry standard. These starting points refer to fresh harvest yield, and the curing adjusted yield. The fresh harvest yield is more relevant for processing and local consumption, while curing adjusted yield is more important for potential export, mainland or if curing is more widely adopted locally. Each tier is a point of assessment for the breeding line.

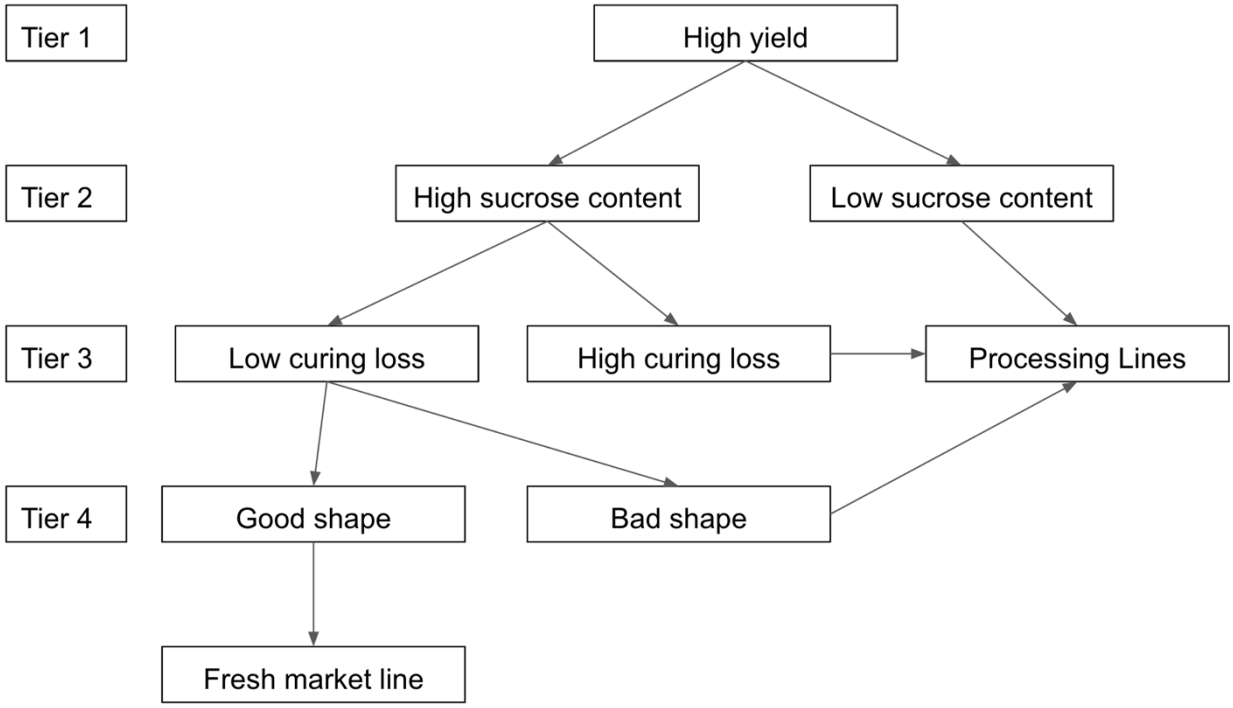


Figure 2.3 Sources of loss that were measured, (A) the effects of cracking, (B) the effects of weevil damage and (C) sprouting during curing. The burrowing nature of the weevil damage demonstrates how infestation will be unsalable for fresh market sales.

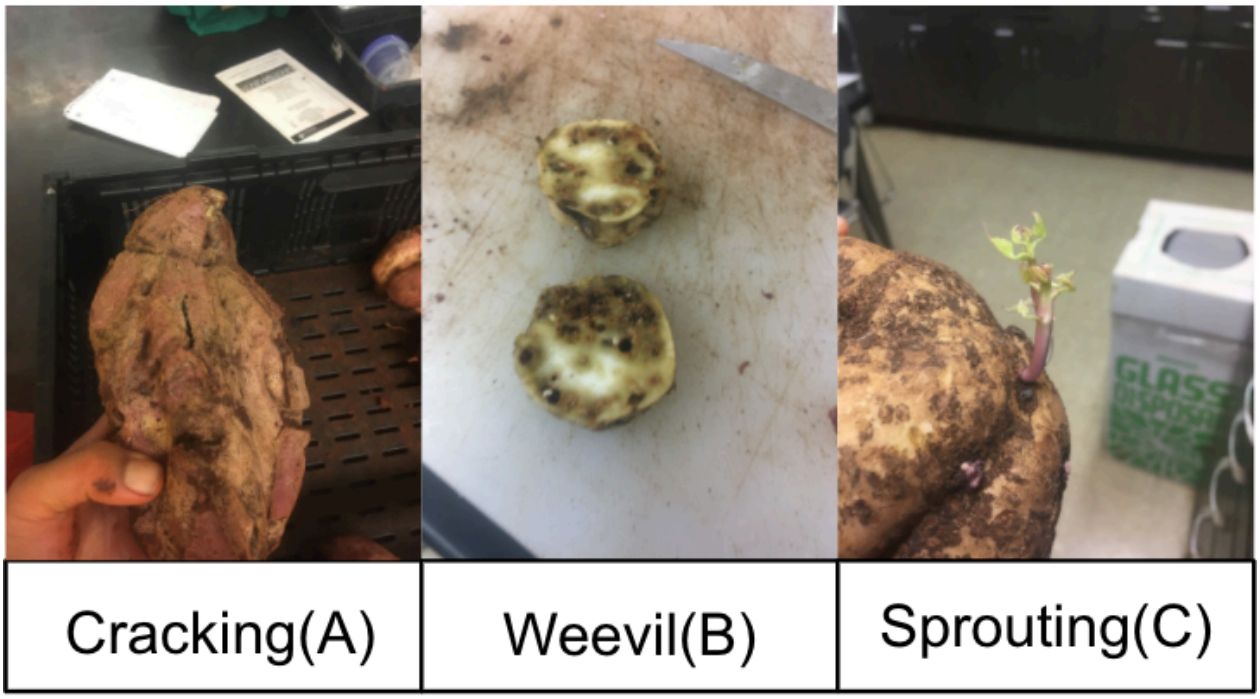
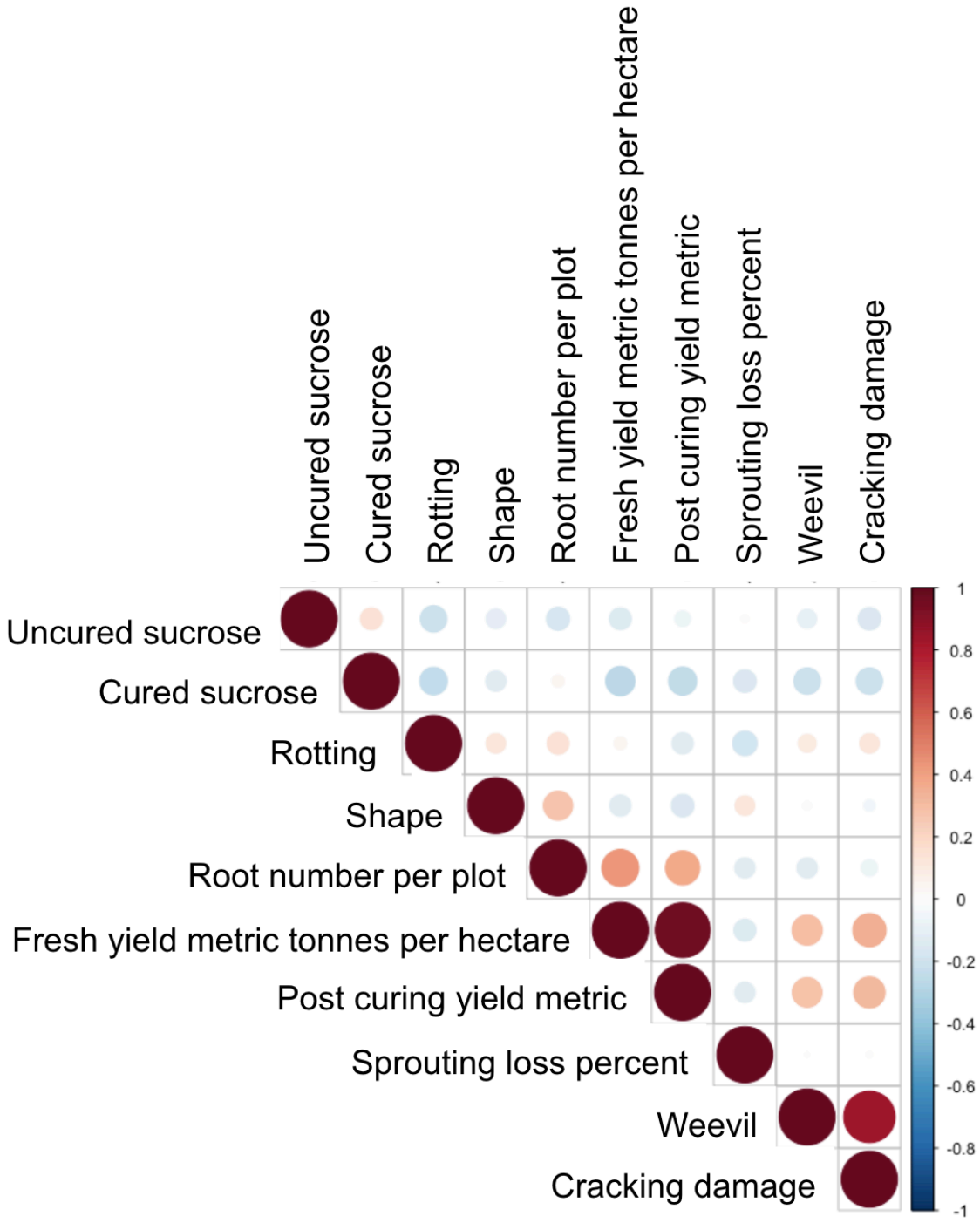


Figure 2.4 Correlation matrix demonstrating the strong correlations of the phenotypes of post curing loss or rotting and the sources of loss negatively affect aspects of yield and can vary by line. The red gradient is positive correlation and blue gradient is a negative correlation. Weevil damage is highly corelated with cracking and other sources of loss during curing.



APPENDICES

Appendix 1: Other Work

There is a growing local alcohol market for liquor, beer and producing segment in Hawai'i. Like many food related industries in Hawai'i there is an interest and price premium that is being targeted in using local produce such as sweet potatoes. The project seeks to develop protocols and explore the utilization of the Hawaiian descent breeding lines used in my thesis work. Different combinations of freezing and boiling followed by examination of sucrose levels were used to develop a protocol for preparing 'Hawaiian Heritage' sweet potato for the brewing. Briefly, after boiling sweet potato are inoculated with koji (*Aspergillus oryzae*) which converts the starch and simple sugars into ethanol for a sake like product. This initial product is then subject to distillation to produce a soju like product, which has potential as a local product. This will help create opportunities for local brewers and distilleries as well as create a market for the "Hawaiian Heritage" lines selected for processing once the cultivars are released to Hawai'i growers.

Appendix 2: Conferences Attended

5. **Testers Symposium (Honolulu, Hawai'i, 2019):** A University of Hawai'i at Manoa event hosted by the biology department. The Ph.D. Student and I presented in a poster competition on the Sugarcane SNP research we are involved in and the research's implications.

- **CTAHR Symposium (Honolulu, Hawai'i, 2019):** A University of Hawai'i at Manoa event hosted by the College of Tropical Agriculture and Human Resources. I gave a presentation about my sweet potato thesis project.

- **American Society of Horticultural Scientists (Las Vegas, Nevada, 2019)**: National conference with both industry and academia participating. I presented a poster on my sweet potato research and volunteered to function as a co-chair in the associated graduate interest group.

- **Minorities in Agriculture Natural Resources and Related Sciences Region IX (San Luis Obispo, California, 2019):** Organization meant to foster minorities in agricultural and related sciences. I was invited to attend to gather information and connections to form a chapter at the University of Hawai'i at Manoa.

- **International Graduate Student Conference (East-West Center, Honolulu, Hawai'i, 2020):** Conference hosted by a Federally funded think-tank organization. I will be presenting a poster on sweet potato breeding in Hawai'i. Special focus will be placed on discussing the collaboration with the Waimanalo Research Hui.

- **American Society of Horticultural Sciences (Online, 2020):** National Conference, I am a co-chair in the graduate interest group and will be leading a tour group and on a tour I arranged. I Will also participate in the interest group meeting and I intend to present on the sweet potato research from my masters.

Appendix 3: Experience with the Community

During my research I worked with an indigenous research vetting organization the Waimanalo Pono Research, a facet of the Waimanalo Hui, a representative organization of the Native Hawaiian community of Waimanalo. The reason for this was that a large proportion of the research was conducted in Waimanalo. My collaboration consisted of attending community meeting and giving short talks about my research, the goals of screening progeny of traditional Hawaiian germplasm for potential use by organic Hawai'i farmers. My goal was to be present and be a point of open communication and dialogue between myself and the community. Their input and concerns have been used in outlining the project in a way the community sees as ethical.

Appendix 4: Raw Data

ENV	Line	block	Yield_Lbs	Yield_Kg	Tuber_number
Nalo18	HM3	Block1	17.32391983	7.858	132
Nalo18	HM4	Block1	11.64922275	5.284	36
Nalo18	HM12	Block1	22.09251726	10.021	54
Nalo18	HM16	Block1	22.18952063	10.065	31
Nalo18	HM17	Block1	6.058301311	2.748	44
Nalo18	HM18	Block1	21.64938824	9.82	135
Nalo18	HM26	Block1	26.55467223	12.045	11
Nalo18	HM32	Block1	12.23565221	5.55	47
Nalo18	HM34	Block1	21.02107096	9.535	24
Nalo18	HM35	Block1	32.21614158	14.613	70
Nalo18	HM39	Block1	12.38777113	5.619	30
Nalo18	HM46	Block1	21.4950647	9.75	32
Nalo18	Okinawa	Block1	NA	NA	NA
Nalo18	Lanikeha	Block1	NA	NA	NA
Nalo18	Purple Kahanu	Block1	NA	NA	NA
Nalo18	Mohihi Ly	Block1	NA	NA	NA
Nalo18	HM3	Block2	8.551728816	3.879	45
Nalo18	HM4	Block2	4.565772203	2.071	8
Nalo18	HM12	Block2	10.62186889	4.818	8
Nalo18	HM16	Block2	23.12648499	10.49	44
Nalo18	HM17	Block2	2.480199773	1.125	9
Nalo18	HM18	Block2	18.59157749	8.433	32
Nalo18	HM26	Block2	27.07496303	12.281	55
Nalo18	HM32	Block2	14.2065843	6.444	50
Nalo18	HM34	Block2	25.18560196	11.424	51
Nalo18	HM35	Block2	20.70801463	9.393	15
Nalo18	HM39	Block2	6.583001352	2.986	36
Nalo18	HM46	Block2	11.37805425	5.161	15
Nalo18	Okinawa	Block2	NA	NA	NA
Nalo18	Lanikeha	Block2	NA	NA	NA

Nalo18	Purple Kahanu	Block2	NA	NA	NA
Nalo18	Mohihi Ly	Block2	NA	NA	NA
Nalo18	HM3	Block3	11.06058867	5.017	22
Nalo18	HM4	Block3	7.76026951	3.52	20
Nalo18	HM12	Block3	9.634198227	4.37	18
Nalo18	HM16	Block3	18.70401322	8.484	20
Nalo18	HM17	Block3	0.7142975345	0.324	2
Nalo18	HM18	Block3	8.249695599	3.742	19
Nalo18	HM26	Block3	11.41553282	5.178	17
Nalo18	HM32	Block3	12.73610141	5.777	29
Nalo18	HM34	Block3	18.57394052	8.425	34
Nalo18	HM35	Block3	20.67714993	9.379	20
Nalo18	HM39	Block3	8.260718709	3.747	31
Nalo18	HM46	Block3	15.59108693	7.072	10
Nalo18	Okinawa	Block3	NA	NA	NA
Nalo18	Lanikeha	Block3	NA	NA	NA
Nalo18	Purple Kahanu	Block3	NA	NA	NA
Nalo18	Mohihi Ly	Block3	NA	NA	NA
Nalo19	HM3	Block1	2.02	0.9162568375	37
Nalo19	HM4	Block1	2.16	0.9797597867	26
Nalo19	HM12	Block1	2.34	1.061406436	29
Nalo19	HM16	Block1	2.47	1.12037346	17
Nalo19	HM17	Block1	0.25	0.1133981235	3
Nalo19	HM18	Block1	1.88	0.8527538884	4
Nalo19	HM26	Block1	1.52	0.6894605906	21
Nalo19	HM32	Block1	2.47	1.12037346	58
Nalo19	HM34	Block1	3.94	1.787154426	34
Nalo19	HM35	Block1	3.84	1.741795176	30
Nalo19	HM39	Block1	0.44	0.1995806973	23
Nalo19	HM46	Block1	4.88	2.21353137	44
Nalo19	Okinawa	Block1	1.07	0.4853439684	13
Nalo19	Lanikeha	Block1	0	0	0
Nalo19	Purple Kahanu	Block1	0.82	0.3719458449	11

Nalo19	Mohihi Ly	Block1	3.72	1.687364077	25
Nalo19	HM3	Block2	5.38	2.440327617	64
Nalo19	HM4	Block2	1.45	0.6577091161	29
Nalo19	HM12	Block2	3.24	1.46963968	47
Nalo19	HM16	Block2	8.37	3.796569173	71
Nalo19	HM17	Block2	0	0	0
Nalo19	HM18	Block2	1.12	0.5080235931	16
Nalo19	HM26	Block2	4	1.814369975	26
Nalo19	HM32	Block2	0.38	0.1723651477	8
Nalo19	HM34	Block2	4.65	2.109205096	51
Nalo19	HM35	Block2	6.54	2.96649491	38
Nalo19	HM39	Block2	1.88	0.8527538884	46
Nalo19	HM46	Block2	3.87	1.755402951	21
Nalo19	Okinawa	Block2	2.41	1.09315791	16
Nalo19	Lanikeha	Block2	1.13	0.512559518	29
Nalo19	Purple Kahanu	Block2	0.57	0.2585477215	11
Nalo19	Mohihi Ly	Block2	3.8	1.723651477	14
Nalo19	HM3	Block3	3.48	1.578501879	47
Nalo19	HM4	Block3	1.81	0.8210024138	18
Nalo19	HM12	Block3	6.61	2.998246384	52
Nalo19	HM16	Block3	4.14	1.877872924	35
Nalo19	HM17	Block3	0.04	0.01814369975	14
Nalo19	HM18	Block3	4.39	1.991271048	13
Nalo19	HM26	Block3	1.65	0.7484276148	26
Nalo19	HM32	Block3	6.38	2.893920111	45
Nalo19	HM34	Block3	7.15	3.243186331	42
Nalo19	HM35	Block3	2.95	1.338097857	7
Nalo19	HM39	Block3	0.32	0.145149598	4
Nalo19	HM46	Block3	3.54	1.605717428	38
Nalo19	Okinawa	Block3	2.56	1.161196784	28
Nalo19	Lanikeha	Block3	0.04	0.01814369975	2
Nalo19	Purple Kahanu	Block3	1.65	0.7484276148	26
Nalo19	Mohihi Ly	Block3	5	2.267962469	1.47

Nalo19	HM3	Block4	0	0	0
Nalo19	HM4	Block4	0	0	0
Nalo19	HM12	Block4	0	0	0
Nalo19	HM16	Block4	6.97	3.161539682	23
Nalo19	HM17	Block4	0	0	0
Nalo19	HM18	Block4	0.825	0.3742138074	4
Nalo19	HM26	Block4	0.115	0.05216313679	3
Nalo19	HM32	Block4	0.04	0.01814369975	3
Nalo19	HM34	Block4	1.94	0.879969438	21
Nalo19	HM35	Block4	1.91	0.8663616632	8
Nalo19	HM39	Block4	0.345	0.1564894104	11
Nalo19	HM46	Block4	1.42	0.6441013412	6
Nalo19	Okinawa	Block4	0.005	0.002267962469	1
Nalo19	Lanikeha	Block4	0	0	0
Nalo19	Purple Kahanu	Block4	5	2.267962469	5
Nalo19	Mohihi Ly	Block4	0.105	0.04762721185	4
Poamoho	HM3	Block1	18.16	8.237239688	39
Poamoho	HM4	Block1	5.27	2.390432442	22
Poamoho	HM12	Block1	22.5	10.20583111	39
Poamoho	HM16	Block1	12.37	5.610939149	14
Poamoho	HM17	Block1	4.09	1.8551933	16
Poamoho	HM18	Block1	12.3	5.579187674	6
Poamoho	HM26	Block1	31.32	14.20651691	25
Poamoho	HM32	Block1	5.3	2.404040217	27
Poamoho	HM34	Block1	10.79	4.894263008	15
Poamoho	HM35	Block1	22.53	10.21943889	54
Poamoho	HM39	Block1	15.24	6.912749606	53
Poamoho	HM46	Block1	10.58	4.799008585	10
Poamoho	Okinawa	Block1	12.77	5.792376146	13
Poamoho	Lanikeha	Block1	0.39	0.1769010726	3
Poamoho	Purple Kahanu	Block1	8.53	3.869143972	37
Poamoho	Mohihi Ly	Block1	6.9	3.129788207	15
Poamoho	HM3	Block2	11.49	5.211777754	56

Poamoho	HM4	Block2	9.43	4.277377217	25
Poamoho	HM12	Block2	17.27	7.833542368	16
Poamoho	HM16	Block2	13.64	6.187001616	17
Poamoho	HM17	Block2	0	0	0
Poamoho	HM18	Block2	7.19	3.261330031	13
Poamoho	HM26	Block2	18.4	8.346101886	24
Poamoho	HM32	Block2	16.76	7.602210197	57
Poamoho	HM34	Block2	9.62	4.363559791	18
Poamoho	HM35	Block2	7.4	3.356584454	47
Poamoho	HM39	Block2	13.42	6.087211267	91
Poamoho	HM46	Block2	8.42	3.819248798	10
Poamoho	Okinawa	Block2	1.2	0.5443109926	4
Poamoho	Lanikeha	Block2	0.43	0.1950447723	7
Poamoho	Purple Kahanu	Block2	5.34	2.422183917	27
Poamoho	Mohihi Ly	Block2	0	0	0
Poamoho	HM3	Block3	9.64	4.372631641	18
Poamoho	HM4	Block3	8.32	3.773889549	21
Poamoho	HM12	Block3	13.29	6.028244243	15
Poamoho	HM16	Block3	18.23	8.268991162	17
Poamoho	HM17	Block3	0.85	0.3855536198	5
Poamoho	HM18	Block3	15.13	6.862854432	18
Poamoho	HM26	Block3	23.32	10.57777696	24
Poamoho	HM32	Block3	20.8	9.434723872	22
Poamoho	HM34	Block3	5.6	2.540117965	22
Poamoho	HM35	Block3	10.16	4.608499737	8
Poamoho	HM39	Block3	12.79	5.801447996	17
Poamoho	HM46	Block3	20.97	9.511834596	9
Poamoho	Okinawa	Block3	4.26	1.932304024	9
Poamoho	Lanikeha	Block3	0.03	0.01360777481	1
Poamoho	Purple Kahanu	Block3	12.5	5.669906173	19
Poamoho	Mohihi Ly	Block3	10.04	4.554068638	15
Poamoho	HM3	Block4	11.51	5.220849604	22
Poamoho	HM4	Block4	9.13	4.141299469	19

Poamoho	HM12	Block4	16	7.257479901	12.19
Poamoho	HM16	Block4	8.13	3.687706975	21
Poamoho	HM17	Block4	0.84	0.3810176948	5
Poamoho	HM18	Block4	10.02	4.544996788	17
Poamoho	HM26	Block4	18.32	8.309814487	16
Poamoho	HM32	Block4	3.89	1.764474801	31
Poamoho	HM34	Block4	9.15	4.150371319	21
Poamoho	HM35	Block4	13.15	5.964741294	15
Poamoho	HM39	Block4	15.44	7.003468105	24
Poamoho	HM46	Block4	11.52	5.225385529	25
Poamoho	Okinawa	Block4	3.21	1.456031905	4
Poamoho	Lanikeha	Block4	0.46	0.2086525472	1
Poamoho	Purple Kahanu	Block4	11.62	5.270744778	14
Poamoho	Mohihi Ly	Block4	24	10.88621985	8.36

ENV	Line	block	Avg_tuber_weight_Kg	Yield_per_acre_UStons	Yield_rot_adjusted
Nalo18	HM3	Block1	0.05953030303	1.267964151	0.2294373342
Nalo18	HM4	Block1	0.1467777778	0.8526244051	0.1392452544
Nalo18	HM12	Block1	0.1855740741	1.61698508	0.4730789306
Nalo18	HM16	Block1	0.3246774194	1.624084905	0.3272329698
Nalo18	HM17	Block1	0.06245454545	0.4434163257	0.1555191905
Nalo18	HM18	Block1	0.07274074074	1.58455179	0.414046449
Nalo18	HM26	Block1	1.095	1.943577017	0.5842680095
Nalo18	HM32	Block1	0.1180851064	0.8955460727	0.2086066119
Nalo18	HM34	Block1	0.3972916667	1.538564289	0.5181956431
Nalo18	HM35	Block1	0.2087571429	2.357948605	0.5201900754
Nalo18	HM39	Block1	0.1873	0.9066798887	0.1776879071
Nalo18	HM46	Block1	0.3046875	1.573256614	0.1987267438
Nalo18	Okinawa	Block1	NA	NA	NA
Nalo18	Lanikeha	Block1	NA	NA	NA
Nalo18	Purple Kahanu	Block1	NA	NA	NA
Nalo18	Mohihi Ly	Block1	NA	NA	NA
Nalo18	HM3	Block2	0.0862	0.625914093	0.1175591543

Nalo18	HM4	Block2	0.258875	0.3341758408	0.0920846392
Nalo18	HM12	Block2	0.60225	0.7774308069	0.1785223691
Nalo18	HM16	Block2	0.2384090909	1.692662757	0.4381915069
Nalo18	HM17	Block2	0.125	0.1815296093	0.03705617495
Nalo18	HM18	Block2	0.26353125	1.360745952	0.2894719539
Nalo18	HM26	Block2	0.2232909091	1.981657895	0.6751492968
Nalo18	HM32	Block2	0.12888	1.039801602	0.3667520866
Nalo18	HM34	Block2	0.224	1.843372673	0.5843514948
Nalo18	HM35	Block2	0.6262	1.515651218	0.556865293
Nalo18	HM39	Block2	0.08294444444	0.4818199231	0.1573578953
Nalo18	HM46	Block2	0.3440666667	0.8327771678	0.1632047141
Nalo18	Okinawa	Block2	NA	NA	NA
Nalo18	Lanikeha	Block2	NA	NA	NA
Nalo18	Purple Kahanu	Block2	NA	NA	NA
Nalo18	Mohihi Ly	Block2	NA	NA	NA
Nalo18	HM3	Block3	0.2280454545	0.8095413778	0.1487167664
Nalo18	HM4	Block3	0.176	0.5679859776	0.1356443937
Nalo18	HM12	Block3	0.2427777778	0.7051416825	0.1007546755
Nalo18	HM16	Block3	0.4242	1.368975294	0.3520825722
Nalo18	HM17	Block3	0.162	0.05228052749	0.01920838442
Nalo18	HM18	Block3	0.1169375	0.6038078205	0.09341892235
Nalo18	HM26	Block3	0.3045882353	0.8355202819	0.2528274431
Nalo18	HM32	Block3	0.1992068966	0.9321747139	0.2592308604
Nalo18	HM34	Block3	0.2477941176	1.359455074	0.3966848559
Nalo18	HM35	Block3	0.46895	1.513392183	0.5282335359
Nalo18	HM39	Block3	0.1208709677	0.6046146188	0.07883798596
Nalo18	HM46	Block3	0.7072	1.141135464	0.2934851427
Nalo18	Okinawa	Block3	NA	NA	NA
Nalo18	Lanikeha	Block3	NA	NA	NA
Nalo18	Purple Kahanu	Block3	NA	NA	NA
Nalo18	Mohihi Ly	Block3	NA	NA	NA
Nalo19	HM3	Block1	0.02476369831	0.1478468851	0
Nalo19	HM4	Block1	0.03768306872	0.1580936989	0

Nalo19	HM12	Block1	0.03660022192	0.1712681739	0
Nalo19	HM16	Block1	0.06590432116	0.1807830724	0
Nalo19	HM17	Block1	0.03779937449	0.01829788182	0
Nalo19	HM18	Block1	0.2131884721	0.1376000713	0
Nalo19	HM26	Block1	0.0328314567	0.1112511215	0
Nalo19	HM32	Block1	0.01931678379	0.1807830724	0
Nalo19	HM34	Block1	0.05256336546	0.2883746175	0
Nalo19	HM35	Block1	0.05805983921	0.2810554648	0
Nalo19	HM39	Block1	0.008677421621	0.03220427201	0
Nalo19	HM46	Block1	0.05030753113	0.3571746532	0
Nalo19	Okinawa	Block1	0.03733415142	0.0783149342	0
Nalo19	Lanikeha	Block1	0	0	0
Nalo19	Purple Kahanu	Block1	0.03381325863	0.06001705238	0
Nalo19	Mohihi Ly	Block1	0.06749456308	0.2722724815	0
Nalo19	HM3	Block2	0.03813011901	0.3937704168	0
Nalo19	HM4	Block2	0.02267962469	0.1061277146	0
Nalo19	HM12	Block2	0.03126892936	0.2371405484	0
Nalo19	HM16	Block2	0.05347280526	0.6126130834	0
Nalo19	HM17	Block2	0	0	0
Nalo19	HM18	Block2	0.03175147457	0.08197451056	0
Nalo19	HM26	Block2	0.06978346059	0.2927661092	0
Nalo19	HM32	Block2	0.02154564346	0.02781278037	0
Nalo19	HM34	Block2	0.04135696267	0.3403406019	0
Nalo19	HM35	Block2	0.07806565552	0.4786725885	0
Nalo19	HM39	Block2	0.01853812801	0.1376000713	0
Nalo19	HM46	Block2	0.08359061672	0.2832512106	0
Nalo19	Okinawa	Block2	0.06832236938	0.1763915808	0
Nalo19	Lanikeha	Block2	0.01767446614	0.08270642584	0
Nalo19	Purple Kahanu	Block2	0.02350433832	0.04171917055	0
Nalo19	Mohihi Ly	Block2	0.1231179626	0.2781278037	0
Nalo19	HM3	Block3	0.03358514635	0.254706515	0
Nalo19	HM4	Block3	0.04561124521	0.1324766644	0
Nalo19	HM12	Block3	0.05765858431	0.4837959954	0

Nalo19	HM16	Block3	0.05365351213	0.303012923	0
Nalo19	HM17	Block3	0.001295978554	0.002927661092	0
Nalo19	HM18	Block3	0.153174696	0.3213108048	0
Nalo19	HM26	Block3	0.02878567749	0.12076602	0
Nalo19	HM32	Block3	0.06430933579	0.4669619441	0
Nalo19	HM34	Block3	0.07721872216	0.5233194201	0
Nalo19	HM35	Block3	0.1911568367	0.2159150055	0
Nalo19	HM39	Block3	0.03628739951	0.02342128873	0
Nalo19	HM46	Block3	0.04225572179	0.2590980066	0
Nalo19	Okinawa	Block3	0.04147131372	0.1873703099	0
Nalo19	Lanikeha	Block3	0.009071849877	0.002927661092	0
Nalo19	Purple Kahanu	Block3	0.02878567749	0.12076602	0
Nalo19	Mohihi Ly	Block3	1.542831612	0.3659576364	0
Nalo19	HM3	Block4	0	0	0
Nalo19	HM4	Block4	0	0	0
Nalo19	HM12	Block4	0	0	0
Nalo19	HM16	Block4	0.137458247	0.5101449452	0
Nalo19	HM17	Block4	0	0	0
Nalo19	HM18	Block4	0.09355345185	0.06038301001	0
Nalo19	HM26	Block4	0.01738771226	0.008417025638	0
Nalo19	HM32	Block4	0.006047899918	0.002927661092	0
Nalo19	HM34	Block4	0.04190330657	0.1419915629	0
Nalo19	HM35	Block4	0.1082952079	0.1397958171	0
Nalo19	HM39	Block4	0.01422631003	0.02525107691	0
Nalo19	HM46	Block4	0.1073502235	0.1039319687	0
Nalo19	Okinawa	Block4	0.002267962469	0.0003659576364	0
Nalo19	Lanikeha	Block4	0	0	0
Nalo19	Purple Kahanu	Block4	0.4535924938	0.3659576364	0
Nalo19	Mohihi Ly	Block4	0.01190680296	0.007685110365	0
Poamoho	HM3	Block1	0.2112112741	2.411584646	1.07661809
Poamoho	HM4	Block1	0.1086560201	0.6998376149	0.3118646699
Poamoho	HM12	Block1	0.2616879772	2.987921506	1.333915585
Poamoho	HM16	Block1	0.4007813678	1.642692845	0.7328335289

Poamoho	HM17	Block1	0.1159495813	0.5431377315	0.2143732179
Poamoho	HM18	Block1	0.9298646123	1.63339709	0.6417023239
Poamoho	HM26	Block1	0.5682606764	4.159186736	1.856810494
Poamoho	HM32	Block1	0.08903852656	0.7038215103	0.3137458798
Poamoho	HM34	Block1	0.3262842005	1.432874358	0.6396866294
Poamoho	HM35	Block1	0.1892488683	2.991905401	1.334952829
Poamoho	HM39	Block1	0.1304292378	2.023818833	0.9035054896
Poamoho	HM46	Block1	0.4799008585	1.40498709	0.6253550401
Poamoho	Okinawa	Block1	0.4455673958	1.69581145	0.7564890131
Poamoho	Lanikeha	Block1	0.0589670242	0.05179063943	0.02312120347
Poamoho	Purple Kahanu	Block1	0.1045714587	1.132754242	0.5057022197
Poamoho	Mohihi Ly	Block1	0.2086525471	0.9162959288	0.4090674462
Poamoho	HM3	Block2	0.09306745989	1.525831916	0.6811862253
Poamoho	HM4	Block2	0.1710950887	1.252271102	0.558611596
Poamoho	HM12	Block2	0.489596398	2.293395752	1.021934591
Poamoho	HM16	Block2	0.3639412715	1.811344415	0.8081737841
Poamoho	HM17	Block2	0	0	0
Poamoho	HM18	Block2	0.2508715408	0.9548069164	0.4262601356
Poamoho	HM26	Block2	0.3477542453	2.443455809	1.090399276
Poamoho	HM32	Block2	0.1333721087	2.225669531	0.9932711314
Poamoho	HM34	Block2	0.2424199884	1.277502439	0.5703230189
Poamoho	HM35	Block2	0.07141669051	0.9826941842	0.4386170081
Poamoho	HM39	Block2	0.06689243151	1.782129182	0.7952572685
Poamoho	HM46	Block2	0.3819248798	1.118146626	0.4991808546
Poamoho	Okinawa	Block2	0.1360777482	0.1593558136	0.07096430912
Poamoho	Lanikeha	Block2	0.0278635389	0.05710249989	0.02549260896
Poamoho	Purple Kahanu	Block2	0.08971051544	0.7091333707	0.316348361
Poamoho	Mohihi Ly	Block2	0	0	0
Poamoho	HM3	Block3	0.2429239801	1.280158369	0.570420569
Poamoho	HM4	Block3	0.1797090261	1.104866974	0.4932523407
Poamoho	HM12	Block3	0.4018829495	1.764865636	0.7860463324
Poamoho	HM16	Block3	0.4864112448	2.420880402	1.076444977
Poamoho	HM17	Block3	0.07711072396	0.1128770347	0.05033638062

Poamoho	HM18	Block3	0.3812696907	2.009211217	0.8969841245
Poamoho	HM26	Block3	0.4407407067	3.096814645	1.382529397
Poamoho	HM32	Block3	0.4288510851	2.762167436	1.233130852
Poamoho	HM34	Block3	0.1154599075	0.7436604636	0.3319967678
Poamoho	HM35	Block3	0.5760624671	1.349212555	0.6016286445
Poamoho	HM39	Block3	0.3412616468	1.69846738	0.7574152384
Poamoho	HM46	Block3	1.056870511	2.784742843	1.237684503
Poamoho	Okinawa	Block3	0.2147004471	0.5657131384	0.2525546841
Poamoho	Lanikeha	Block3	0.01360777481	0.003983895341	0.001778554113
Poamoho	Purple Kahanu	Block3	0.2984161144	1.659956392	0.7410642137
Poamoho	Mohihi Ly	Block3	0.3036045759	1.333276974	0.5938704304
Poamoho	HM3	Block4	0.2373113456	1.528487846	0.682371928
Poamoho	HM4	Block4	0.2179631299	1.212432149	0.5412733016
Poamoho	HM12	Block4	0.5953634045	2.124744182	0.9485621936
Poamoho	HM16	Block4	0.175605094	1.079635638	0.4810241884
Poamoho	HM17	Block4	0.07620353896	0.1115490695	0.04979951515
Poamoho	HM18	Block4	0.2673527522	1.330621044	0.592180708
Poamoho	HM26	Block4	0.5193634054	2.432832088	1.086103712
Poamoho	HM32	Block4	0.05691854197	0.5165784292	0.2301800844
Poamoho	HM34	Block4	0.1976367295	1.215088079	0.5424590043
Poamoho	HM35	Block4	0.3976494196	1.746274125	0.779599553
Poamoho	HM39	Block4	0.291811171	2.050378136	0.914264082
Poamoho	HM46	Block4	0.2090154212	1.529815811	0.6812573676
Poamoho	Okinawa	Block4	0.3640079763	0.4262768015	0.1903052901
Poamoho	Lanikeha	Block4	0.2086525472	0.06108639522	0.02727116307
Poamoho	Purple Kahanu	Block4	0.3764817699	1.543095462	0.6888932931
Poamoho	Mohihi Ly	Block4	1.302179408	3.187116273	1.421064736

ENV	Line	block	Yield_Rot_lost_tonnes	Yield_Metrictonnes_Hectare	Yield_per_acre_metric_tonnes
Nalo18	HM3	Block1	0.2364252733	0.4658626074	1.150278043
Nalo18	HM4	Block1	0.1740174101	0.3132626645	0.7734880604
Nalo18	HM12	Block1	0.1210174283	0.594096359	1.46690459
Nalo18	HM16	Block1	0.269471935	0.5967049048	1.473345444

Nalo18	HM17	Block1	0.007396366277	0.1629155568	0.402260634
Nalo18	HM18	Block1	0.1681335974	0.5821800464	1.437481596
Nalo18	HM26	Block1	0.1298214668	0.7140894763	1.763183892
Nalo18	HM32	Block1	0.120425899	0.3290325109	0.8124259529
Nalo18	HM34	Block1	0.04708813905	0.5652837821	1.395762425
Nalo18	HM35	Block1	0.3461436333	0.8663337087	2.139095577
Nalo18	HM39	Block1	0.1554352783	0.3331231854	0.8225263837
Nalo18	HM46	Block1	0.3793033429	0.5780300867	1.427234782
Nalo18	Okinawa	Block1	NA	NA	NA
Nalo18	Lanikeha	Block1	NA	NA	NA
Nalo18	Purple Kahanu	Block1	NA	NA	NA
Nalo18	Mohihi Ly	Block1	NA	NA	NA
Nalo18	HM3	Block2	0.1124078925	0.2299670468	0.5678198687
Nalo18	HM4	Block2	0.03069487973	0.1227795189	0.303159306
Nalo18	HM12	Block2	0.1071134215	0.2856357905	0.7052735569
Nalo18	HM16	Block2	0.1837095815	0.6219010884	1.535558243
Nalo18	HM17	Block2	0.0296396043	0.06669577924	0.1646809364
Nalo18	HM18	Block2	0.2104796072	0.4999515611	1.234448299
Nalo18	HM26	Block2	0.05293147188	0.7280807687	1.797730293
Nalo18	HM32	Block2	0.01528133694	0.3820334235	0.9432924037
Nalo18	HM34	Block2	0.09292191131	0.6772734061	1.672280015
Nalo18	HM35	Block2	0	0.556865293	1.374976032
Nalo18	HM39	Block2	0.0196675241	0.1770254194	0.437099801
Nalo18	HM46	Block2	0.1427658785	0.3059705926	0.7554829447
Nalo18	Okinawa	Block2	NA	NA	NA
Nalo18	Lanikeha	Block2	NA	NA	NA
Nalo18	Purple Kahanu	Block2	NA	NA	NA
Nalo18	Mohihi Ly	Block2	NA	NA	NA
Nalo18	HM3	Block3	0.1487167664	0.2974335328	0.7344037848
Nalo18	HM4	Block3	0.07303928891	0.2086836826	0.5152683521
Nalo18	HM12	Block3	0.1583213736	0.2590760491	0.6396939485
Nalo18	HM16	Block3	0.150892531	0.5029751032	1.241913835

Nalo18	HM17	Block3	0	0.01920838442	0.04742810968
Nalo18	HM18	Block3	0.1284260607	0.221844983	0.5477653902
Nalo18	HM26	Block3	0.0541509968	0.3069784399	0.7579714566
Nalo18	HM32	Block3	0.08325937663	0.3424902371	0.8456549063
Nalo18	HM34	Block3	0.1027924243	0.4994772802	1.233277235
Nalo18	HM35	Block3	0.02780176505	0.5560353009	1.372926669
Nalo18	HM39	Block3	0.1433034228	0.2221414087	0.5484973055
Nalo18	HM46	Block3	0.1257793469	0.4192644896	1.035220962
Nalo18	Okinawa	Block3	NA	NA	NA
Nalo18	Lanikeha	Block3	NA	NA	NA
Nalo18	Purple Kahanu	Block3	NA	NA	NA
Nalo18	Mohihi Ly	Block3	NA	NA	NA
Nalo19	HM3	Block1	0.06600416504	0.06600416504	0.162973247
Nalo19	HM4	Block1	0.07057871115	0.07057871115	0.1742684226
Nalo19	HM12	Block1	0.0764602704	0.0764602704	0.1887907911
Nalo19	HM16	Block1	0.0807080632	0.0807080632	0.1992791684
Nalo19	HM17	Block1	0.00816883231	0.00816883231	0.02016995632
Nalo19	HM18	Block1	0.06142961896	0.06142961896	0.1516780715
Nalo19	HM26	Block1	0.04966650043	0.04966650043	0.1226333344
Nalo19	HM32	Block1	0.0807080632	0.0807080632	0.1992791684
Nalo19	HM34	Block1	0.1287407972	0.1287407972	0.3178785116
Nalo19	HM35	Block1	0.1254732642	0.1254732642	0.309810529
Nalo19	HM39	Block1	0.01437714486	0.01437714486	0.03549912312
Nalo19	HM46	Block1	0.1594556067	0.1594556067	0.3937175473
Nalo19	Okinawa	Block1	0.03496260228	0.03496260228	0.08632741304
Nalo19	Lanikeha	Block1	0	0	0
Nalo19	Purple Kahanu	Block1	0.02679376997	0.02679376997	0.06615745672
Nalo19	Mohihi Ly	Block1	0.1215522248	0.1215522248	0.30012895
Nalo19	HM3	Block2	0.1757932713	0.1757932713	0.43405746
Nalo19	HM4	Block2	0.04737922737	0.04737922737	0.1169857466
Nalo19	HM12	Block2	0.1058680667	0.1058680667	0.2614026339
Nalo19	HM16	Block2	0.2734925057	0.2734925057	0.6752901375

Nalo19	HM17	Block2	0	0	0
Nalo19	HM18	Block2	0.03659636874	0.03659636874	0.0903614043
Nalo19	HM26	Block2	0.1307013169	0.1307013169	0.3227193011
Nalo19	HM32	Block2	0.01241662511	0.01241662511	0.0306583336
Nalo19	HM34	Block2	0.1519402809	0.1519402809	0.3751611875
Nalo19	HM35	Block2	0.2136966532	0.2136966532	0.5276460573
Nalo19	HM39	Block2	0.06142961896	0.06142961896	0.1516780715
Nalo19	HM46	Block2	0.1264535241	0.1264535241	0.3122309238
Nalo19	Okinawa	Block2	0.07874754345	0.07874754345	0.1944383789
Nalo19	Lanikeha	Block2	0.03692312204	0.03692312204	0.09116820256
Nalo19	Purple Kahanu	Block2	0.01862493766	0.01862493766	0.0459875004
Nalo19	Mohihi Ly	Block2	0.1241662511	0.1241662511	0.306583336
Nalo19	HM3	Block3	0.1137101457	0.1137101457	0.2807657919
Nalo19	HM4	Block3	0.0591423459	0.0591423459	0.1460304837
Nalo19	HM12	Block3	0.2159839262	0.2159839262	0.533293645
Nalo19	HM16	Block3	0.135275863	0.135275863	0.3340144766
Nalo19	HM17	Block3	0.001307013169	0.001307013169	0.003227193011
Nalo19	HM18	Block3	0.1434446953	0.1434446953	0.3541844329
Nalo19	HM26	Block3	0.05391429324	0.05391429324	0.1331217117
Nalo19	HM32	Block3	0.2084686005	0.2084686005	0.5147372852
Nalo19	HM34	Block3	0.233628604	0.233628604	0.5768607507
Nalo19	HM35	Block3	0.09639222122	0.09639222122	0.2380054845
Nalo19	HM39	Block3	0.01045610536	0.01045610536	0.02581754409
Nalo19	HM46	Block3	0.1156706655	0.1156706655	0.2856065815
Nalo19	Okinawa	Block3	0.08364884284	0.08364884284	0.2065403527
Nalo19	Lanikeha	Block3	0.001307013169	0.001307013169	0.003227193011
Nalo19	Purple Kahanu	Block3	0.05391429324	0.05391429324	0.1331217117
Nalo19	Mohihi Ly	Block3	0.1633766462	0.1633766462	0.4033991264
Nalo19	HM3	Block4	0	0	0
Nalo19	HM4	Block4	0	0	0
Nalo19	HM12	Block4	0	0	0
Nalo19	HM16	Block4	0.2277470448	0.2277470448	0.5623383821

Nalo19	HM17	Block4	0	0	0
Nalo19	HM18	Block4	0.02695714662	0.02695714662	0.06656085585
Nalo19	HM26	Block4	0.003757662862	0.003757662862	0.009278179906
Nalo19	HM32	Block4	0.001307013169	0.001307013169	0.003227193011
Nalo19	HM34	Block4	0.06339013871	0.06339013871	0.156518861
Nalo19	HM35	Block4	0.06240987885	0.06240987885	0.1540984663
Nalo19	HM39	Block4	0.01127298859	0.01127298859	0.02783453972
Nalo19	HM46	Block4	0.04639896752	0.04639896752	0.1145653519
Nalo19	Okinawa	Block4	0.0001633766462	0.0001633766462	0.0004033991264
Nalo19	Lanikeha	Block4	0	0	0
Nalo19	Purple Kahanu	Block4	0.1633766462	0.1633766462	0.4033991264
Nalo19	Mohihi Ly	Block4	0.003430909569	0.003430909569	0.008471381653
Poamoho	HM3	Block1	0	1.07661809	2.658316271
Poamoho	HM4	Block1	0.0005680025987	0.3124326725	0.7714386976
Poamoho	HM12	Block1	0	1.333915585	3.293618728
Poamoho	HM16	Block1	0.0005236170022	0.7333571459	1.810758385
Poamoho	HM17	Block1	0.02810299283	0.2424762107	0.5987066932
Poamoho	HM18	Block1	0.08750486235	0.7292071863	1.800511571
Poamoho	HM26	Block1	0	1.856810494	4.584717269
Poamoho	HM32	Block1	0.0004653468267	0.3142112267	0.7758301893
Poamoho	HM34	Block1	0	0.6396866294	1.579473159
Poamoho	HM35	Block1	0.0007413102472	1.335694139	3.29801022
Poamoho	HM39	Block1	0	0.9035054896	2.230877752
Poamoho	HM46	Block1	0.001881710251	0.6272367504	1.548732717
Poamoho	Okinawa	Block1	0.0005821877534	0.7570712008	1.869311607
Poamoho	Lanikeha	Block1	0	0.02312120347	0.05708939128
Poamoho	Purple Kahanu	Block1	0	0.5057022197	1.248647456
Poamoho	Mohihi Ly	Block1	0	0.4090674462	1.010043077
Poamoho	HM3	Block2	0	0.6811862253	1.681941297
Poamoho	HM4	Block2	0.0004472470744	0.559058843	1.380392205
Poamoho	HM12	Block2	0.001919726846	1.023854318	2.528035353
Poamoho	HM16	Block2	0.0004754857707	0.8086492699	1.996664864

Poamoho	HM17	Block2	0	0	0
Poamoho	HM18	Block2	0	0.4262601356	1.052494162
Poamoho	HM26	Block2	0.0004472470743	1.090846523	2.693448204
Poamoho	HM32	Block2	0.0003477666143	0.993618898	2.453379995
Poamoho	HM34	Block2	0	0.5703230189	1.408204985
Poamoho	HM35	Block2	0.0000930065231	0.4387100146	1.083234604
Poamoho	HM39	Block2	0.000349271271	0.7956065398	1.964460592
Poamoho	HM46	Block2	0	0.4991808546	1.23254532
Poamoho	Okinawa	Block2	0.0001778554113	0.07114216453	0.1756596655
Poamoho	Lanikeha	Block2	0	0.02549260896	0.06294471347
Poamoho	Purple Kahanu	Block2	0.0002342711478	0.3165826321	0.7816855114
Poamoho	Mohihi Ly	Block2	0	0	0
Poamoho	HM3	Block3	0.001088152606	0.5715087216	1.411132646
Poamoho	HM4	Block3	0	0.4932523407	1.217907014
Poamoho	HM12	Block3	0.001853139558	0.787899472	1.945430795
Poamoho	HM16	Block3	0.004323072198	1.080768049	2.668563085
Poamoho	HM17	Block3	0.00005598591923	0.05039236654	0.1244255964
Poamoho	HM18	Block3	0	0.8969841245	2.214775616
Poamoho	HM26	Block3	0	1.382529397	3.413652833
Poamoho	HM32	Block3	0	1.233130852	3.044767535
Poamoho	HM34	Block3	0	0.3319967678	0.8197451056
Poamoho	HM35	Block3	0.0007083483035	0.6023369928	1.487251834
Poamoho	HM39	Block3	0.0008416651629	0.7582569035	1.872239268
Poamoho	HM46	Block3	0.00552482224	1.243209325	3.069652654
Poamoho	Okinawa	Block3	0	0.2525546841	0.6235918125
Poamoho	Lanikeha	Block3	0	0.001778554113	0.004391491637
Poamoho	Purple Kahanu	Block3	0	0.7410642137	1.829788182
Poamoho	Mohihi Ly	Block3	0.001352346148	0.5952227765	1.469685868
Poamoho	HM3	Block4	0	0.682371928	1.684868958
Poamoho	HM4	Block4	0	0.5412733016	1.336477288
Poamoho	HM12	Block4	0	0.9485621936	2.342128873
Poamoho	HM16	Block4	0.0009639763295	0.4819881648	1.190094234

Poamoho	HM17	Block4	0	0.04979951515	0.1229617658
Poamoho	HM18	Block4	0.001856365856	0.5940370738	1.466758207
Poamoho	HM26	Block4	0	1.086103712	2.68173756
Poamoho	HM32	Block4	0.0004390989251	0.2306191833	0.5694300823
Poamoho	HM34	Block4	0	0.5424590043	1.339404949
Poamoho	HM35	Block4	0	0.779599553	1.924937168
Poamoho	HM39	Block4	0.00109843502	0.915362517	2.260154363
Poamoho	HM46	Block4	0.001707411949	0.6829647795	1.686332789
Poamoho	Okinawa	Block4	0	0.1903052901	0.4698896052
Poamoho	Lanikeha	Block4	0	0.02727116307	0.0673362051
Poamoho	Purple Kahanu	Block4	0	0.6888932931	1.700971094
Poamoho	Mohihi Ly	Block4	0.001778554113	1.422843291	3.51319331

ENV	Line	block	Avg_tuber_length	Avg_tuber_width	Avg_tuber_diameter
Nalo18	HM3	Block1	10.74	3.83	NA
Nalo18	HM4	Block1	11.88	3.67	NA
Nalo18	HM12	Block1	13.85	4.65	NA
Nalo18	HM16	Block1	13.46	5.46	NA
Nalo18	HM17	Block1	12.11	3.14	NA
Nalo18	HM18	Block1	12.46	3.42	NA
Nalo18	HM26	Block1	13.02	5.03	NA
Nalo18	HM32	Block1	12.95	3.09	NA
Nalo18	HM34	Block1	17.2	6.02	NA
Nalo18	HM35	Block1	12.83	5.76	NA
Nalo18	HM39	Block1	13.49	4.28	NA
Nalo18	HM46	Block1	11.23	3.66	NA
Nalo18	Okinawa	Block1	NA	NA	NA
Nalo18	Lanikeha	Block1	NA	NA	NA
Nalo18	Purple Kahanu	Block1	NA	NA	NA
Nalo18	Mohihi Ly	Block1	NA	NA	NA
Nalo18	HM3	Block2	11.08	4.07	NA
Nalo18	HM4	Block2	11.29	4.11	NA
Nalo18	HM12	Block2	14.53	6.81	NA

Nalo18	HM16	Block2	13.56	5.05	NA
Nalo18	HM17	Block2	9.38	2.88	NA
Nalo18	HM18	Block2	12.06	4.8	NA
Nalo18	HM26	Block2	11.93	5.28	NA
Nalo18	HM32	Block2	15.54	4.5	NA
Nalo18	HM34	Block2	15.27	4.58	NA
Nalo18	HM35	Block2	12.86	5.35	NA
Nalo18	HM39	Block2	14.5	3.11	NA
Nalo18	HM46	Block2	9.65	3.84	NA
Nalo18	Okinawa	Block2	NA	NA	NA
Nalo18	Lanikeha	Block2	NA	NA	NA
Nalo18	Purple Kahanu	Block2	NA	NA	NA
Nalo18	Mohihi Ly	Block2	NA	NA	NA
Nalo18	HM3	Block3	11.33	4.71	NA
Nalo18	HM4	Block3	10.94	4.05	NA
Nalo18	HM12	Block3	10.95	5.02	NA
Nalo18	HM16	Block3	13.65	4.92	NA
Nalo18	HM17	Block3	11.9	3.3	NA
Nalo18	HM18	Block3	11.4	3.62	NA
Nalo18	HM26	Block3	11.44	4.14	NA
Nalo18	HM32	Block3	14.09	4.58	NA
Nalo18	HM34	Block3	11.81	5.4	NA
Nalo18	HM35	Block3	11.42	7	NA
Nalo18	HM39	Block3	11.31	3	NA
Nalo18	HM46	Block3	13.92	7.01	NA
Nalo18	Okinawa	Block3	NA	NA	NA
Nalo18	Lanikeha	Block3	NA	NA	NA
Nalo18	Purple Kahanu	Block3	NA	NA	NA
Nalo18	Mohihi Ly	Block3	NA	NA	NA
Nalo19	HM3	Block1	NA	NA	NA
Nalo19	HM4	Block1	NA	NA	NA
Nalo19	HM12	Block1	NA	NA	NA
Nalo19	HM16	Block1	NA	NA	NA

Nalo19	HM17	Block1	NA	NA	NA
Nalo19	HM18	Block1	NA	NA	NA
Nalo19	HM26	Block1	NA	NA	NA
Nalo19	HM32	Block1	NA	NA	NA
Nalo19	HM34	Block1	NA	NA	NA
Nalo19	HM35	Block1	NA	NA	NA
Nalo19	HM39	Block1	NA	NA	NA
Nalo19	HM46	Block1	NA	NA	NA
Nalo19	Okinawa	Block1	NA	NA	NA
Nalo19	Lanikeha	Block1	NA	NA	NA
Nalo19	Purple Kahanu	Block1	NA	NA	NA
Nalo19	Mohihi Ly	Block1	NA	NA	NA
Nalo19	HM3	Block2	NA	NA	NA
Nalo19	HM4	Block2	NA	NA	NA
Nalo19	HM12	Block2	NA	NA	NA
Nalo19	HM16	Block2	NA	NA	NA
Nalo19	HM17	Block2	NA	NA	NA
Nalo19	HM18	Block2	NA	NA	NA
Nalo19	HM26	Block2	NA	NA	NA
Nalo19	HM32	Block2	NA	NA	NA
Nalo19	HM34	Block2	NA	NA	NA
Nalo19	HM35	Block2	NA	NA	NA
Nalo19	HM39	Block2	NA	NA	NA
Nalo19	HM46	Block2	NA	NA	NA
Nalo19	Okinawa	Block2	NA	NA	NA
Nalo19	Lanikeha	Block2	NA	NA	NA
Nalo19	Purple Kahanu	Block2	NA	NA	NA
Nalo19	Mohihi Ly	Block2	NA	NA	NA
Nalo19	HM3	Block3	NA	NA	NA
Nalo19	HM4	Block3	NA	NA	NA
Nalo19	HM12	Block3	NA	NA	NA
Nalo19	HM16	Block3	NA	NA	NA
Nalo19	HM17	Block3	NA	NA	NA

Nalo19	HM18	Block3	NA	NA	NA
Nalo19	HM26	Block3	NA	NA	NA
Nalo19	HM32	Block3	NA	NA	NA
Nalo19	HM34	Block3	NA	NA	NA
Nalo19	HM35	Block3	NA	NA	NA
Nalo19	HM39	Block3	NA	NA	NA
Nalo19	HM46	Block3	NA	NA	NA
Nalo19	Okinawa	Block3	NA	NA	NA
Nalo19	Lanikeha	Block3	NA	NA	NA
Nalo19	Purple Kahanu	Block3	NA	NA	NA
Nalo19	Mohihi Ly	Block3	NA	NA	NA
Nalo19	HM3	Block4	NA	NA	NA
Nalo19	HM4	Block4	NA	NA	NA
Nalo19	HM12	Block4	NA	NA	NA
Nalo19	HM16	Block4	NA	NA	NA
Nalo19	HM17	Block4	NA	NA	NA
Nalo19	HM18	Block4	NA	NA	NA
Nalo19	HM26	Block4	NA	NA	NA
Nalo19	HM32	Block4	NA	NA	NA
Nalo19	HM34	Block4	NA	NA	NA
Nalo19	HM35	Block4	NA	NA	NA
Nalo19	HM39	Block4	NA	NA	NA
Nalo19	HM46	Block4	NA	NA	NA
Nalo19	Okinawa	Block4	NA	NA	NA
Nalo19	Lanikeha	Block4	NA	NA	NA
Nalo19	Purple Kahanu	Block4	NA	NA	NA
Nalo19	Mohihi Ly	Block4	NA	NA	NA
Poamoho	HM3	Block1	11.65	3.65	NA
Poamoho	HM4	Block1	10.3	3.46	NA
Poamoho	HM12	Block1	16	7.66	NA
Poamoho	HM16	Block1	16.72	7.72	NA
Poamoho	HM17	Block1	11.42	4.33	NA
Poamoho	HM18	Block1	10.33	4.53	NA

Poamoho	HM26	Block1	15.42	7.3	NA
Poamoho	HM32	Block1	13.78	3.16	NA
Poamoho	HM34	Block1	11.62	2.96	NA
Poamoho	HM35	Block1	9.74	3.96	NA
Poamoho	HM39	Block1	12.18	5.16	NA
Poamoho	HM46	Block1	12.35	6.23	NA
Poamoho	Okinawa	Block1	9.73	2.6	NA
Poamoho	Lanikeha	Block1	NA	NA	NA
Poamoho	Purple Kahanu	Block1	6.75	3.5	NA
Poamoho	Mohihi Ly	Block1	8.34	3.12	NA
Poamoho	HM3	Block2	9.23	5.72	NA
Poamoho	HM4	Block2	12.67	6.23	NA
Poamoho	HM12	Block2	16.16	7.2	NA
Poamoho	HM16	Block2	11.44	6.6	NA
Poamoho	HM17	Block2	0	0	NA
Poamoho	HM18	Block2	10.96	5.66	NA
Poamoho	HM26	Block2	11.02	5.7	NA
Poamoho	HM32	Block2	11.8	2.36	NA
Poamoho	HM34	Block2	13.14	5.08	NA
Poamoho	HM35	Block2	10.92	5.6	NA
Poamoho	HM39	Block2	13.54	4.14	NA
Poamoho	HM46	Block2	11.96	7.86	NA
Poamoho	Okinawa	Block2	14.1	4.975	NA
Poamoho	Lanikeha	Block2	6.82	2.08	NA
Poamoho	Purple Kahanu	Block2	7.06	3.35	NA
Poamoho	Mohihi Ly	Block2	0	0	NA
Poamoho	HM3	Block3	11.46	5.38	NA
Poamoho	HM4	Block3	20.825	7.15	NA
Poamoho	HM12	Block3	14.44	5.52	NA
Poamoho	HM16	Block3	16.94	6.86	NA
Poamoho	HM17	Block3	9.8	3.3	NA
Poamoho	HM18	Block3			NA
Poamoho	HM26	Block3	14.66	6.73	NA

Poamoho	HM32	Block3	9.48	5.98	NA
Poamoho	HM34	Block3	18.32	4.38	NA
Poamoho	HM35	Block3	8.275	4.15	NA
Poamoho	HM39	Block3	7.5	2.96	NA
Poamoho	HM46	Block3	10.82	6.86	NA
Poamoho	Okinawa	Block3	9.31	5.76	NA
Poamoho	Lanikeha	Block3	NA	NA	NA
Poamoho	Purple Kahanu	Block3	12.35	5.9	NA
Poamoho	Mohihi Ly	Block3	6.84	2.6	NA
Poamoho	HM3	Block4	8.1	3.46	NA
Poamoho	HM4	Block4	10.28	4.28	NA
Poamoho	HM12	Block4	16.27	7.13	NA
Poamoho	HM16	Block4	13.84	6.92	NA
Poamoho	HM17	Block4	13.3	3.06	NA
Poamoho	HM18	Block4	10.15	5.92	NA
Poamoho	HM26	Block4	12.8	5.92	NA
Poamoho	HM32	Block4	11.8	2.86	NA
Poamoho	HM34	Block4	17.4	4.25	NA
Poamoho	HM35	Block4	11.725	7.95	NA
Poamoho	HM39	Block4	15.82	7.99	NA
Poamoho	HM46	Block4	11.86	6.36	NA
Poamoho	Okinawa	Block4	8.9	5.5	NA
Poamoho	Lanikeha	Block4	NA	NA	NA
Poamoho	Purple Kahanu	Block4	10.04	4.87	NA
Poamoho	Mohihi Ly	Block4	7.56	4.28	NA

ENV	Line	block	Lengthbywidth	Skin_color	Flesh_color
Nalo18	HM3	Block1	2.804177546	violet	W
Nalo18	HM4	Block1	3.237057221	violet	WCLVR
Nalo18	HM12	Block1	2.978494624	violet	W
Nalo18	HM16	Block1	2.465201465	violet	PLYS
Nalo18	HM17	Block1	3.856687898	white	OC
Nalo18	HM18	Block1	3.643274854	white	WOS

Nalo18	HM26	Block1	2.588469185	white	W
Nalo18	HM32	Block1	4.190938511	deep purple	DP
Nalo18	HM34	Block1	2.857142857	violet	SP
Nalo18	HM35	Block1	2.227430556	white	WLPS
Nalo18	HM39	Block1	3.151869159	violet	WCPR
Nalo18	HM46	Block1	3.068306011	violet	W
Nalo18	Okinawa	Block1	NA	NA	NA
Nalo18	Lanikeha	Block1	NA	NA	NA
Nalo18	Purple Kahanu	Block1	NA	NA	NA
Nalo18	Mohihi Ly	Block1	NA	NA	NA
Nalo18	HM3	Block2	2.722358722	violet	W
Nalo18	HM4	Block2	2.746958637	violet	WCLVR
Nalo18	HM12	Block2	2.133627019	violet	W
Nalo18	HM16	Block2	2.685148515	violet	PLYS
Nalo18	HM17	Block2	3.256944444	pinkish biege	OC
Nalo18	HM18	Block2	2.5125	white	WOS
Nalo18	HM26	Block2	2.259469697	white	W
Nalo18	HM32	Block2	3.453333333	violet	DP
Nalo18	HM34	Block2	3.334061135	violet	SP
Nalo18	HM35	Block2	2.403738318	white	WLPS
Nalo18	HM39	Block2	4.662379421	violet	WCPR
Nalo18	HM46	Block2	2.513020833	violet	W
Nalo18	Okinawa	Block2	NA	NA	NA
Nalo18	Lanikeha	Block2	NA	NA	NA
Nalo18	Purple Kahanu	Block2	NA	NA	NA
Nalo18	Mohihi Ly	Block2	NA	NA	NA
Nalo18	HM3	Block3	2.40552017	violet	W
Nalo18	HM4	Block3	2.701234568	violet	WCLVR
Nalo18	HM12	Block3	2.1812749	violet	W
Nalo18	HM16	Block3	2.774390244	violet	PLYS
Nalo18	HM17	Block3	3.606060606	white	OC
Nalo18	HM18	Block3	3.149171271	white	WOS
Nalo18	HM26	Block3	2.763285024	white	W

Nalo18	HM32	Block3	3.076419214	purple	DP
Nalo18	HM34	Block3	2.187037037	violet	SP
Nalo18	HM35	Block3	1.631428571	white	WLPS
Nalo18	HM39	Block3	3.77	violet	WCPR
Nalo18	HM46	Block3	1.985734665	violet	W
Nalo18	Okinawa	Block3	NA	NA	NA
Nalo18	Lanikeha	Block3	NA	NA	NA
Nalo18	Purple Kahanu	Block3	NA	NA	NA
Nalo18	Mohihi Ly	Block3	NA	NA	NA
Nalo19	HM3	Block1	NA	violet	W
Nalo19	HM4	Block1	NA	violet	WCLVR
Nalo19	HM12	Block1	NA	violet	W
Nalo19	HM16	Block1	NA	violet	PLYS
Nalo19	HM17	Block1	NA	white	OC
Nalo19	HM18	Block1	NA	white	WOS
Nalo19	HM26	Block1	NA	white	W
Nalo19	HM32	Block1	NA	deep purple	DP
Nalo19	HM34	Block1	NA	violet	SP
Nalo19	HM35	Block1	NA	white	WLPS
Nalo19	HM39	Block1	NA	violet	WCPR
Nalo19	HM46	Block1	NA	violet	W
Nalo19	Okinawa	Block1	NA	white	LP
Nalo19	Lanikeha	Block1	NA	NA	NA
Nalo19	Purple Kahanu	Block1	NA	violet	W
Nalo19	Mohihi Ly	Block1	NA	violet	DP
Nalo19	HM3	Block2	NA	violet	W
Nalo19	HM4	Block2	NA	violet	WCLVR
Nalo19	HM12	Block2	NA	violet	W
Nalo19	HM16	Block2	NA	violet	PLYS
Nalo19	HM17	Block2	NA	NA	NA
Nalo19	HM18	Block2	NA	white	WOS
Nalo19	HM26	Block2	NA	white	W
Nalo19	HM32	Block2	NA	deep purple	DP

Nalo19	HM34	Block2	NA	violet	SP
Nalo19	HM35	Block2	NA	white	WLPS
Nalo19	HM39	Block2	NA	violet	WCPR
Nalo19	HM46	Block2	NA	violet	W
Nalo19	Okinawa	Block2	NA	white	LP
Nalo19	Lanikeha	Block2	NA	tan	W
Nalo19	Purple Kahanu	Block2	NA	violet	W
Nalo19	Mohihi Ly	Block2	NA	violet	DP
Nalo19	HM3	Block3	NA	violet	W
Nalo19	HM4	Block3	NA	violet	WCLVR
Nalo19	HM12	Block3	NA	violet	W
Nalo19	HM16	Block3	NA	violet	PLYS
Nalo19	HM17	Block3	NA	white	OC
Nalo19	HM18	Block3	NA	white	WOS
Nalo19	HM26	Block3	NA	white	W
Nalo19	HM32	Block3	NA	deep purple	DP
Nalo19	HM34	Block3	NA	violet	SP
Nalo19	HM35	Block3	NA	white	WLPS
Nalo19	HM39	Block3	NA	violet	WCPR
Nalo19	HM46	Block3	NA	violet	W
Nalo19	Okinawa	Block3	NA	white	LP
Nalo19	Lanikeha	Block3	NA	tan	W
Nalo19	Purple Kahanu	Block3	NA	violet	W
Nalo19	Mohihi Ly	Block3	NA	violet	DP
Nalo19	HM3	Block4	NA	NA	NA
Nalo19	HM4	Block4	NA	NA	NA
Nalo19	HM12	Block4	NA	NA	NA
Nalo19	HM16	Block4	NA	violet	PLYS
Nalo19	HM17	Block4	NA	white	NA
Nalo19	HM18	Block4	NA	white	WOS
Nalo19	HM26	Block4	NA	white	W
Nalo19	HM32	Block4	NA	deep purple	DP
Nalo19	HM34	Block4	NA	violet	SP

Nalo19	HM35	Block4	NA	white	WLPS
Nalo19	HM39	Block4	NA	violet	WCPR
Nalo19	HM46	Block4	NA	violet	W
Nalo19	Okinawa	Block4	NA	white	LP
Nalo19	Lanikeha	Block4	NA	NA	NA
Nalo19	Purple Kahanu	Block4	NA	violet	W
Nalo19	Mohihi Ly	Block4	NA	violet	DP
Poamoho	HM3	Block1	3.191780822	violet	W
Poamoho	HM4	Block1	2.976878613	violet	WCLVR
Poamoho	HM12	Block1	2.088772846	violet	W
Poamoho	HM16	Block1	2.165803109	violet	PLYS
Poamoho	HM17	Block1	2.637413395	white	OC
Poamoho	HM18	Block1	2.280353201	white	WOS
Poamoho	HM26	Block1	2.112328767	white	W
Poamoho	HM32	Block1	4.360759494	deep purple	DP
Poamoho	HM34	Block1	3.925675676	violet	SP
Poamoho	HM35	Block1	2.45959596	white	WLPS
Poamoho	HM39	Block1	2.360465116	violet	WCPR
Poamoho	HM46	Block1	1.982343499	violet	W
Poamoho	Okinawa	Block1	3.742307692	white	LP
Poamoho	Lanikeha	Block1	NA	NA	NA
Poamoho	Purple Kahanu	Block1	1.928571429	violet	W
Poamoho	Mohihi Ly	Block1	2.673076923	violet	DP
Poamoho	HM3	Block2	1.613636364	violet	W
Poamoho	HM4	Block2	2.033707865	violet	WCLVR
Poamoho	HM12	Block2	2.244444444	violet	W
Poamoho	HM16	Block2	1.733333333	violet	PLYS
Poamoho	HM17	Block2	NA	NA	NA
Poamoho	HM18	Block2	1.93639576	white	WOS
Poamoho	HM26	Block2	1.933333333	white	W
Poamoho	HM32	Block2	5	deep purple	DP
Poamoho	HM34	Block2	2.586614173	violet	SP
Poamoho	HM35	Block2	1.95	white	WLPS

Poamoho	HM39	Block2	3.270531401	violet	WCPR
Poamoho	HM46	Block2	1.521628499	violet	W
Poamoho	Okinawa	Block2	2.834170854	white	LP
Poamoho	Lanikeha	Block2	3.278846154	tan	W
Poamoho	Purple Kahanu	Block2	2.107462687	violet	W
Poamoho	Mohihi Ly	Block2	NA	NA	NA
Poamoho	HM3	Block3	2.130111524	violet	W
Poamoho	HM4	Block3	2.912587413	violet	WCLVR
Poamoho	HM12	Block3	2.615942029	violet	W
Poamoho	HM16	Block3	2.469387755	violet	PLYS
Poamoho	HM17	Block3	2.96969697	white	OC
Poamoho	HM18	Block3	NA	white	WOS
Poamoho	HM26	Block3	2.178306092	white	W
Poamoho	HM32	Block3	1.585284281	deep purple	DP
Poamoho	HM34	Block3	4.182648402	violet	SP
Poamoho	HM35	Block3	1.993975904	white	WLPS
Poamoho	HM39	Block3	2.533783784	violet	WCPR
Poamoho	HM46	Block3	1.577259475	violet	W
Poamoho	Okinawa	Block3	1.616319444	white	LP
Poamoho	Lanikeha	Block3	NA	tan	NA
Poamoho	Purple Kahanu	Block3	2.093220339	violet	W
Poamoho	Mohihi Ly	Block3	2.630769231	violet	DP
Poamoho	HM3	Block4	2.341040462	violet	W
Poamoho	HM4	Block4	2.401869159	violet	WCLVR
Poamoho	HM12	Block4	2.281907433	violet	W
Poamoho	HM16	Block4	2	violet	PLYS
Poamoho	HM17	Block4	4.346405229	white	OC
Poamoho	HM18	Block4	1.714527027	white	WOS
Poamoho	HM26	Block4	2.162162162	white	W
Poamoho	HM32	Block4	4.125874126	deep purple	DP
Poamoho	HM34	Block4	4.094117647	violet	SP
Poamoho	HM35	Block4	1.474842767	white	WLPS
Poamoho	HM39	Block4	1.979974969	violet	WCPR

Poamoho	HM46	Block4	1.864779874	violet	W
Poamoho	Okinawa	Block4	1.618181818	white	LP
Poamoho	Lanikeha	Block4	NA	tan	W
Poamoho	Purple Kahanu	Block4	2.061601643	violet	W
Poamoho	Mohihi Ly	Block4	1.76635514	violet	DP

ENV	Line	block	Vine_color	Weevil_Damage	Cracking
Nalo18	HM3	Block1	NA	0.1439393939	0.02272727273
Nalo18	HM4	Block1	NA	0.02777777778	0.05555555556
Nalo18	HM12	Block1	NA	0.2592592593	0
Nalo18	HM16	Block1	NA	0	0.09677419355
Nalo18	HM17	Block1	NA	0.06818181818	0.02272727273
Nalo18	HM18	Block1	NA	0.05925925926	0
Nalo18	HM26	Block1	NA	2.727272727	0.8181818182
Nalo18	HM32	Block1	NA	0.1489361702	0
Nalo18	HM34	Block1	NA	0.9583333333	0
Nalo18	HM35	Block1	NA	0	0.01428571429
Nalo18	HM39	Block1	NA	0.2666666667	0.1
Nalo18	HM46	Block1	NA	0.15625	0.15625
Nalo18	Okinawa	Block1	NA	NA	NA
Nalo18	Lanikeha	Block1	NA	NA	NA
Nalo18	Purple Kahanu	Block1	NA	NA	NA
Nalo18	Mohihi Ly	Block1	NA	NA	NA
Nalo18	HM3	Block2	NA	0.04444444444	0.1333333333
Nalo18	HM4	Block2	NA	0.625	0
Nalo18	HM12	Block2	NA	0.25	0
Nalo18	HM16	Block2	NA	0.2272727273	0.02272727273
Nalo18	HM17	Block2	NA	0	0
Nalo18	HM18	Block2	NA	0.28125	0.21875
Nalo18	HM26	Block2	NA	0.2	0.01818181818
Nalo18	HM32	Block2	NA	0	0
Nalo18	HM34	Block2	NA	0.1568627451	0.05882352941
Nalo18	HM35	Block2	NA	0.1333333333	0.2

Nalo18	HM39	Block2	NA	0.2777777778	0.08333333333
Nalo18	HM46	Block2	NA	0.1333333333	0
Nalo18	Okinawa	Block2	NA	NA	NA
Nalo18	Lanikeha	Block2	NA	NA	NA
Nalo18	Purple Kahanu	Block2	NA	NA	NA
Nalo18	Mohihi Ly	Block2	NA	NA	NA
Nalo18	HM3	Block3	NA	0.1818181818	0.04545454545
Nalo18	HM4	Block3	NA	0.35	0.05
Nalo18	HM12	Block3	NA	0.3888888889	0
Nalo18	HM16	Block3	NA	0.2	0
Nalo18	HM17	Block3	NA	0	0
Nalo18	HM18	Block3	NA	0.3157894737	0.05263157895
Nalo18	HM26	Block3	NA	0.1764705882	0
Nalo18	HM32	Block3	NA	0.1379310345	0
Nalo18	HM34	Block3	NA	0.4117647059	0.05882352941
Nalo18	HM35	Block3	NA	0.65	0.2
Nalo18	HM39	Block3	NA	0.1935483871	0
Nalo18	HM46	Block3	NA	0.7	0.1
Nalo18	Okinawa	Block3	NA	NA	NA
Nalo18	Lanikeha	Block3	NA	NA	NA
Nalo18	Purple Kahanu	Block3	NA	NA	NA
Nalo18	Mohihi Ly	Block3	NA	NA	NA
Nalo19	HM3	Block1	NA	100	NA
Nalo19	HM4	Block1	NA	100	NA
Nalo19	HM12	Block1	NA	100	NA
Nalo19	HM16	Block1	NA	100	NA
Nalo19	HM17	Block1	NA	100	NA
Nalo19	HM18	Block1	NA	100	NA
Nalo19	HM26	Block1	NA	100	NA
Nalo19	HM32	Block1	NA	100	NA
Nalo19	HM34	Block1	NA	100	NA
Nalo19	HM35	Block1	NA	100	NA
Nalo19	HM39	Block1	NA	100	NA

Nalo19	HM46	Block1	NA	100	NA
Nalo19	Okinawa	Block1	NA	100	NA
Nalo19	Lanikeha	Block1	NA	100	NA
Nalo19	Purple Kahanu	Block1	NA	100	NA
Nalo19	Mohihi Ly	Block1	NA	100	NA
Nalo19	HM3	Block2	NA	100	NA
Nalo19	HM4	Block2	NA	100	NA
Nalo19	HM12	Block2	NA	100	NA
Nalo19	HM16	Block2	NA	100	NA
Nalo19	HM17	Block2	NA	100	NA
Nalo19	HM18	Block2	NA	100	NA
Nalo19	HM26	Block2	NA	100	NA
Nalo19	HM32	Block2	NA	100	NA
Nalo19	HM34	Block2	NA	100	NA
Nalo19	HM35	Block2	NA	100	NA
Nalo19	HM39	Block2	NA	100	NA
Nalo19	HM46	Block2	NA	100	NA
Nalo19	Okinawa	Block2	NA	100	NA
Nalo19	Lanikeha	Block2	NA	100	NA
Nalo19	Purple Kahanu	Block2	NA	100	NA
Nalo19	Mohihi Ly	Block2	NA	100	NA
Nalo19	HM3	Block3	NA	100	NA
Nalo19	HM4	Block3	NA	100	NA
Nalo19	HM12	Block3	NA	100	NA
Nalo19	HM16	Block3	NA	100	NA
Nalo19	HM17	Block3	NA	100	NA
Nalo19	HM18	Block3	NA	100	NA
Nalo19	HM26	Block3	NA	100	NA
Nalo19	HM32	Block3	NA	100	NA
Nalo19	HM34	Block3	NA	100	NA
Nalo19	HM35	Block3	NA	100	NA
Nalo19	HM39	Block3	NA	100	NA
Nalo19	HM46	Block3	NA	100	NA

Nalo19	Okinawa	Block3	NA	100	NA
Nalo19	Lanikeha	Block3	NA	100	NA
Nalo19	Purple Kahanu	Block3	NA	100	NA
Nalo19	Mohihi Ly	Block3	NA	100	NA
Nalo19	HM3	Block4	NA	100	NA
Nalo19	HM4	Block4	NA	100	NA
Nalo19	HM12	Block4	NA	100	NA
Nalo19	HM16	Block4	NA	100	NA
Nalo19	HM17	Block4	NA	100	NA
Nalo19	HM18	Block4	NA	100	NA
Nalo19	HM26	Block4	NA	100	NA
Nalo19	HM32	Block4	NA	100	NA
Nalo19	HM34	Block4	NA	100	NA
Nalo19	HM35	Block4	NA	100	NA
Nalo19	HM39	Block4	NA	100	NA
Nalo19	HM46	Block4	NA	100	NA
Nalo19	Okinawa	Block4	NA	100	NA
Nalo19	Lanikeha	Block4	NA	100	NA
Nalo19	Purple Kahanu	Block4	NA	100	NA
Nalo19	Mohihi Ly	Block4	NA	100	NA
Poamoho	HM3	Block1	NA	0	0
Poamoho	HM4	Block1	NA	0	0
Poamoho	HM12	Block1	NA	0	0
Poamoho	HM16	Block1	NA	0	0
Poamoho	HM17	Block1	NA	0	0
Poamoho	HM18	Block1	NA	0	0
Poamoho	HM26	Block1	NA	0	0
Poamoho	HM32	Block1	NA	0	0
Poamoho	HM34	Block1	NA	0	0
Poamoho	HM35	Block1	NA	0	0
Poamoho	HM39	Block1	NA	0	0
Poamoho	HM46	Block1	NA	0	0
Poamoho	Okinawa	Block1	NA	0.23	0

Poamoho	Lanikeha	Block1	NA	0.33	0
Poamoho	Purple Kahanu	Block1	NA	0	0
Poamoho	Mohihi Ly	Block1	NA	0	0
Poamoho	HM3	Block2	NA	0.16	0
Poamoho	HM4	Block2	NA	0	0
Poamoho	HM12	Block2	NA	0.11	0
Poamoho	HM16	Block2	NA	0.04	0
Poamoho	HM17	Block2	NA	0	0
Poamoho	HM18	Block2	NA	0	0
Poamoho	HM26	Block2	NA	0	0
Poamoho	HM32	Block2	NA	0.105	0.05
Poamoho	HM34	Block2	NA	0.05	0
Poamoho	HM35	Block2	NA	0	0
Poamoho	HM39	Block2	NA	0	0
Poamoho	HM46	Block2	NA	0	0
Poamoho	Okinawa	Block2	NA	0	0
Poamoho	Lanikeha	Block2	NA	0	0
Poamoho	Purple Kahanu	Block2	NA	0.111	0
Poamoho	Mohihi Ly	Block2	NA	0	0
Poamoho	HM3	Block3	NA		
Poamoho	HM4	Block3	NA		
Poamoho	HM12	Block3	NA	0	0
Poamoho	HM16	Block3	NA	0.189	0
Poamoho	HM17	Block3	NA	2	0
Poamoho	HM18	Block3	NA		
Poamoho	HM26	Block3	NA	0	0
Poamoho	HM32	Block3	NA	0.09	0
Poamoho	HM34	Block3	NA	0	0
Poamoho	HM35	Block3	NA	0	0
Poamoho	HM39	Block3	NA	0	0
Poamoho	HM46	Block3	NA	0	0
Poamoho	Okinawa	Block3	NA	0	0
Poamoho	Lanikeha	Block3	NA	0	0

Poamoho	Purple Kahanu	Block3	NA	0	0
Poamoho	Mohihi Ly	Block3	NA	0	0
Poamoho	HM3	Block4	NA	0	0
Poamoho	HM4	Block4	NA	0	0
Poamoho	HM12	Block4	NA	0	0
Poamoho	HM16	Block4	NA	0	0
Poamoho	HM17	Block4	NA	0	0
Poamoho	HM18	Block4	NA	0	0
Poamoho	HM26	Block4	NA	0.1875	0
Poamoho	HM32	Block4	NA	0	0
Poamoho	HM34	Block4	NA	0.17	0
Poamoho	HM35	Block4	NA	10.37	0
Poamoho	HM39	Block4	NA	0	0
Poamoho	HM46	Block4	NA	0	0
Poamoho	Okinawa	Block4	NA	0	0
Poamoho	Lanikeha	Block4	NA	0	0
Poamoho	Purple Kahanu	Block4	NA	0.2857	0.07
Poamoho	Mohihi Ly	Block4	NA	0	0

ENV	Line	block	Sugar_content_uncured_percent_sucrose	Sugar_content_uncured_UStons_acre	Sugar_content_uncured_acre_sucrose_Metrictonnes
Nalo18	HM3	Block1	3.7	4.691467359	4.256028759
Nalo18	HM4	Block1	9.9	8.44098161	7.657531798
Nalo18	HM12	Block1	14.43	23.33309471	21.16743323
Nalo18	HM16	Block1	6.4	10.39414339	9.429410844
Nalo18	HM17	Block1	14.8	6.562561621	5.953457383
Nalo18	HM18	Block1	4	6.338207159	5.749926384
Nalo18	HM26	Block1	5.7	11.078389	10.05014819
Nalo18	HM32	Block1	12.1	10.83610748	9.83035403
Nalo18	HM34	Block1	8.5	13.07779646	11.86398062
Nalo18	HM35	Block1	3.3	7.781230398	7.059015403
Nalo18	HM39	Block1	4.7	4.261395477	3.865874003

Nalo18	HM46	Block1	6.7	10.54081932	9.56247304
Nalo18	Okinawa	Block1	NA	NA	NA
Nalo18	Lanikeha	Block1	NA	NA	NA
Nalo18	Purple Kahanu	Block1	NA	NA	NA
Nalo18	Mohihi Ly	Block1	NA	NA	NA
Nalo18	HM3	Block2	3.3	2.065516507	1.873805567
Nalo18	HM4	Block2	7.6	2.53973639	2.304010726
Nalo18	HM12	Block2	8.6	6.685904939	6.06535259
Nalo18	HM16	Block2	2.6	4.400923169	3.992451431
Nalo18	HM17	Block2	6.1	1.107330617	1.004553712
Nalo18	HM18	Block2	8.5	11.56634059	10.49281054
Nalo18	HM26	Block2	5.9	11.69178158	10.60660873
Nalo18	HM32	Block2	5.9	6.134829453	5.565425182
Nalo18	HM34	Block2	7.2	13.27228324	12.04041611
Nalo18	HM35	Block2	5.9	8.942342187	8.112358587
Nalo18	HM39	Block2	5.9	2.842737546	2.578888826
Nalo18	HM46	Block2	4.2	3.497664105	3.173028368
Nalo18	Okinawa	Block2	NA	NA	NA
Nalo18	Lanikeha	Block2	NA	NA	NA
Nalo18	Purple Kahanu	Block2	NA	NA	NA
Nalo18	Mohihi Ly	Block2	NA	NA	NA
Nalo18	HM3	Block3	5.7	4.614385853	4.186101573
Nalo18	HM4	Block3	5	2.839929888	2.576341761
Nalo18	HM12	Block3	12.6	8.884785199	8.060143751
Nalo18	HM16	Block3	11.6	15.88011341	14.40620049
Nalo18	HM17	Block3	7.7	0.4025600616	0.3651964446
Nalo18	HM18	Block3	8.9	5.373889603	4.875111973
Nalo18	HM26	Block3	7.2	6.015746029	5.457394487
Nalo18	HM32	Block3	9.1	8.482789896	7.695459647
Nalo18	HM34	Block3	7.7	10.46780407	9.496234708
Nalo18	HM35	Block3	9.2	13.92320808	12.63092535

Nalo18	HM39	Block3	5.7	3.446303327	3.126434641
Nalo18	HM46	Block3	6.9	7.873834703	7.143024638
Nalo18	Okinawa	Block3	NA	NA	NA
Nalo18	Lanikeha	Block3	NA	NA	NA
Nalo18	Purple Kahanu	Block3	NA	NA	NA
Nalo18	Mohihi Ly	Block3	NA	NA	NA
Nalo19	HM3	Block1	4.11	NA	NA
Nalo19	HM4	Block1	NA	NA	NA
Nalo19	HM12	Block1	NA	NA	NA
Nalo19	HM16	Block1	NA	NA	NA
Nalo19	HM17	Block1	7.77	NA	NA
Nalo19	HM18	Block1	19.96	NA	NA
Nalo19	HM26	Block1	9.13	NA	NA
Nalo19	HM32	Block1	NA	NA	NA
Nalo19	HM34	Block1	3.98	NA	NA
Nalo19	HM35	Block1	8.05	NA	NA
Nalo19	HM39	Block1	NA	NA	NA
Nalo19	HM46	Block1	18.11	NA	NA
Nalo19	Okinawa	Block1	NA	NA	NA
Nalo19	Lanikeha	Block1	5.99	NA	NA
Nalo19	Purple Kahanu	Block1	NA	NA	NA
Nalo19	Mohihi Ly	Block1	5.47	NA	NA
Nalo19	HM3	Block2	NA	NA	NA
Nalo19	HM4	Block2	12.68	NA	NA
Nalo19	HM12	Block2	NA	NA	NA
Nalo19	HM16	Block2	NA	NA	NA
Nalo19	HM17	Block2	NA	NA	NA
Nalo19	HM18	Block2	NA	NA	NA
Nalo19	HM26	Block2	NA	NA	NA
Nalo19	HM32	Block2	NA	NA	NA
Nalo19	HM34	Block2	NA	NA	NA

Nalo19	HM35	Block2	NA	NA	NA
Nalo19	HM39	Block2	NA	NA	NA
Nalo19	HM46	Block2	NA	NA	NA
Nalo19	Okinawa	Block2	1.35	NA	NA
Nalo19	Lanikeha	Block2	NA	NA	NA
Nalo19	Purple Kahanu	Block2	17.24	NA	NA
Nalo19	Mohihi Ly	Block2	NA	NA	NA
Nalo19	HM3	Block3	4.92	NA	NA
Nalo19	HM4	Block3	4.65	NA	NA
Nalo19	HM12	Block3	1.7	NA	NA
Nalo19	HM16	Block3	12.34	NA	NA
Nalo19	HM17	Block3	0.096	NA	NA
Nalo19	HM18	Block3	NA	NA	NA
Nalo19	HM26	Block3	2.46	NA	NA
Nalo19	HM32	Block3	13.07	NA	NA
Nalo19	HM34	Block3	9.72	NA	NA
Nalo19	HM35	Block3	4.18	NA	NA
Nalo19	HM39	Block3	7.28	NA	NA
Nalo19	HM46	Block3	NA	NA	NA
Nalo19	Okinawa	Block3	6.53	NA	NA
Nalo19	Lanikeha	Block3	1.6	NA	NA
Nalo19	Purple Kahanu	Block3	26.46	NA	NA
Nalo19	Mohihi Ly	Block3	1.9	NA	NA
Nalo19	HM3	Block4	5.18	NA	NA
Nalo19	HM4	Block4	NA	NA	NA
Nalo19	HM12	Block4	NA	NA	NA
Nalo19	HM16	Block4	14.86	NA	NA
Nalo19	HM17	Block4	NA	NA	NA
Nalo19	HM18	Block4	6.45	NA	NA
Nalo19	HM26	Block4	4.18	NA	NA
Nalo19	HM32	Block4	5.76	NA	NA

Nalo19	HM34	Block4	6.25	NA	NA
Nalo19	HM35	Block4	NA	NA	NA
Nalo19	HM39	Block4	4.74	NA	NA
Nalo19	HM46	Block4	NA	NA	NA
Nalo19	Okinawa	Block4	NA	NA	NA
Nalo19	Lanikeha	Block4	NA	NA	NA
Nalo19	Purple Kahanu	Block4	0.0883	NA	NA
Nalo19	Mohihi Ly	Block4	2.64	NA	NA
Poamoho	HM3	Block1	20.52	NA	NA
Poamoho	HM4	Block1	21.46	NA	NA
Poamoho	HM12	Block1	11.65	NA	NA
Poamoho	HM16	Block1	NA	NA	NA
Poamoho	HM17	Block1	8.67	NA	NA
Poamoho	HM18	Block1	11.5	NA	NA
Poamoho	HM26	Block1	9.45	NA	NA
Poamoho	HM32	Block1	17.54	NA	NA
Poamoho	HM34	Block1	11.13	NA	NA
Poamoho	HM35	Block1	8.32	NA	NA
Poamoho	HM39	Block1	23.34	NA	NA
Poamoho	HM46	Block1	13.07	NA	NA
Poamoho	Okinawa	Block1	14.84	NA	NA
Poamoho	Lanikeha	Block1	NA	NA	NA
Poamoho	Purple Kahanu	Block1	16.41	NA	NA
Poamoho	Mohihi Ly	Block1	11.65	NA	NA
Poamoho	HM3	Block2	NA	NA	NA
Poamoho	HM4	Block2	11.62	NA	NA
Poamoho	HM12	Block2	3.8	NA	NA
Poamoho	HM16	Block2	18.18	NA	NA
Poamoho	HM17	Block2	9.09	NA	NA
Poamoho	HM18	Block2	6.7	NA	NA
Poamoho	HM26	Block2	9.77	NA	NA

Poamoho	HM32	Block2	1.27	NA	NA
Poamoho	HM34	Block2	7.46	NA	NA
Poamoho	HM35	Block2	13.46	NA	NA
Poamoho	HM39	Block2	6.76	NA	NA
Poamoho	HM46	Block2	10.75	NA	NA
Poamoho	Okinawa	Block2	11.61	NA	NA
Poamoho	Lanikeha	Block2	3	NA	NA
Poamoho	Purple Kahanu	Block2		NA	NA
Poamoho	Mohihi Ly	Block2	16.87	NA	NA
Poamoho	HM3	Block3	10.73	NA	NA
Poamoho	HM4	Block3	13.85	NA	NA
Poamoho	HM12	Block3		NA	NA
Poamoho	HM16	Block3	3.87	NA	NA
Poamoho	HM17	Block3	NA	NA	NA
Poamoho	HM18	Block3	24	NA	NA
Poamoho	HM26	Block3	12.97	NA	NA
Poamoho	HM32	Block3	10.32	NA	NA
Poamoho	HM34	Block3	0.17	NA	NA
Poamoho	HM35	Block3	10.9	NA	NA
Poamoho	HM39	Block3	NA	NA	NA
Poamoho	HM46	Block3	NA	NA	NA
Poamoho	Okinawa	Block3	15.46	NA	NA
Poamoho	Lanikeha	Block3	15.4	NA	NA
Poamoho	Purple Kahanu	Block3	6.61	NA	NA
Poamoho	Mohihi Ly	Block3	7.7	NA	NA
Poamoho	HM3	Block4	NA	NA	NA
Poamoho	HM4	Block4	4.65	NA	NA
Poamoho	HM12	Block4	NA	NA	NA
Poamoho	HM16	Block4	NA	NA	NA
Poamoho	HM17	Block4	NA	NA	NA
Poamoho	HM18	Block4	NA	NA	NA

Poamoho	HM26	Block4	NA	NA	NA
Poamoho	HM32	Block4	NA	NA	NA
Poamoho	HM34	Block4	10.32	NA	NA
Poamoho	HM35	Block4	NA	NA	NA
Poamoho	HM39	Block4	NA	NA	NA
Poamoho	HM46	Block4	NA	NA	NA
Poamoho	Okinawa	Block4	NA	NA	NA
Poamoho	Lanikeha	Block4	NA	NA	NA
Poamoho	Purple Kahanu	Block4	NA	NA	NA
Poamoho	Mohihi Ly	Block4	NA	NA	NA

ENV	Line	block	Sugar_content_cured	Percent_rotting_during_curing	Percent_sprouting during storage
Nalo18	HM3	Block1		50.75	7.57
Nalo18	HM4	Block1		55.55	0
Nalo18	HM12	Block1		20.37	1.85
Nalo18	HM16	Block1		45.16	3.22
Nalo18	HM17	Block1		4.54	31.81
Nalo18	HM18	Block1		28.88	0
Nalo18	HM26	Block1		18.18	0
Nalo18	HM32	Block1		36.6	3.33
Nalo18	HM34	Block1		8.33	12.5
Nalo18	HM35	Block1		39.955	10.31
Nalo18	HM39	Block1		46.66	3.33
Nalo18	HM46	Block1		65.62	0
Nalo18	Okinawa	Block1	NA	NA	NA
Nalo18	Lanikeha	Block1	NA	NA	NA
Nalo18	Purple Kahanu	Block1	NA	NA	NA
Nalo18	Mohihi Ly	Block1	NA	NA	NA
Nalo18	HM3	Block2		48.88	0
Nalo18	HM4	Block2		25	25
Nalo18	HM12	Block2		37.5	12.5

Nalo18	HM16	Block2		29.54	4.54
Nalo18	HM17	Block2		44.44	0
Nalo18	HM18	Block2		42.1	2.63
Nalo18	HM26	Block2		7.27	16.36
Nalo18	HM32	Block2		4	32
Nalo18	HM34	Block2		13.72	7.83
Nalo18	HM35	Block2		0	46
Nalo18	HM39	Block2		11.11	25
Nalo18	HM46	Block2		46.66	0
Nalo18	Okinawa	Block2	NA	NA	NA
Nalo18	Lanikeha	Block2	NA	NA	NA
Nalo18	Purple Kahanu	Block2	NA	NA	NA
Nalo18	Mohihi Ly	Block2	NA	NA	NA
Nalo18	HM3	Block3		50	9.09
Nalo18	HM4	Block3		35	5
Nalo18	HM12	Block3		61.11	5.55
Nalo18	HM16	Block3		30	10
Nalo18	HM17	Block3		0	100
Nalo18	HM18	Block3		57.89	21.05
Nalo18	HM26	Block3		17.64	5.88
Nalo18	HM32	Block3		24.31	6.89
Nalo18	HM34	Block3		20.58	11.76
Nalo18	HM35	Block3		5	50
Nalo18	HM39	Block3		64.51	3.22
Nalo18	HM46	Block3		30	10
Nalo18	Okinawa	Block3	NA	NA	NA
Nalo18	Lanikeha	Block3	NA	NA	NA
Nalo18	Purple Kahanu	Block3	NA	NA	NA
Nalo18	Mohihi Ly	Block3	NA	NA	NA
Nalo19	HM3	Block1	NA	100	NA
Nalo19	HM4	Block1	NA	100	NA
Nalo19	HM12	Block1	NA	100	NA

Nalo19	HM16	Block1	NA	100	NA
Nalo19	HM17	Block1	NA	100	NA
Nalo19	HM18	Block1	NA	100	NA
Nalo19	HM26	Block1	NA	100	NA
Nalo19	HM32	Block1	NA	100	NA
Nalo19	HM34	Block1	NA	100	NA
Nalo19	HM35	Block1	NA	100	NA
Nalo19	HM39	Block1	NA	100	NA
Nalo19	HM46	Block1	NA	100	NA
Nalo19	Okinawa	Block1	NA	100	NA
Nalo19	Lanikeha	Block1	NA	100	NA
Nalo19	Purple Kahanu	Block1	NA	100	NA
Nalo19	Mohihi Ly	Block1	NA	100	NA
Nalo19	HM3	Block2	NA	100	NA
Nalo19	HM4	Block2	NA	100	NA
Nalo19	HM12	Block2	NA	100	NA
Nalo19	HM16	Block2	NA	100	NA
Nalo19	HM17	Block2	NA	100	NA
Nalo19	HM18	Block2	NA	100	NA
Nalo19	HM26	Block2	NA	100	NA
Nalo19	HM32	Block2	NA	100	NA
Nalo19	HM34	Block2	NA	100	NA
Nalo19	HM35	Block2	NA	100	NA
Nalo19	HM39	Block2	NA	100	NA
Nalo19	HM46	Block2	NA	100	NA
Nalo19	Okinawa	Block2	NA	100	NA
Nalo19	Lanikeha	Block2	NA	100	NA
Nalo19	Purple Kahanu	Block2	NA	100	NA
Nalo19	Mohihi Ly	Block2	NA	100	NA
Nalo19	HM3	Block3	NA	100	NA
Nalo19	HM4	Block3	NA	100	NA
Nalo19	HM12	Block3	NA	100	NA

Nalo19	HM16	Block3	NA	100	NA
Nalo19	HM17	Block3	NA	100	NA
Nalo19	HM18	Block3	NA	100	NA
Nalo19	HM26	Block3	NA	100	NA
Nalo19	HM32	Block3	NA	100	NA
Nalo19	HM34	Block3	NA	100	NA
Nalo19	HM35	Block3	NA	100	NA
Nalo19	HM39	Block3	NA	100	NA
Nalo19	HM46	Block3	NA	100	NA
Nalo19	Okinawa	Block3	NA	100	NA
Nalo19	Lanikeha	Block3	NA	100	NA
Nalo19	Purple Kahanu	Block3	NA	100	8.32
Nalo19	Mohihi Ly	Block3	NA	100	NA
Nalo19	HM3	Block4	NA	100	NA
Nalo19	HM4	Block4	NA	100	NA
Nalo19	HM12	Block4	NA	100	NA
Nalo19	HM16	Block4	NA	100	NA
Nalo19	HM17	Block4	NA	100	3.25
Nalo19	HM18	Block4	NA	100	NA
Nalo19	HM26	Block4	NA	100	NA
Nalo19	HM32	Block4	NA	100	NA
Nalo19	HM34	Block4	NA	100	NA
Nalo19	HM35	Block4	NA	100	NA
Nalo19	HM39	Block4	NA	100	NA
Nalo19	HM46	Block4	NA	100	NA
Nalo19	Okinawa	Block4	NA	100	NA
Nalo19	Lanikeha	Block4	NA	100	NA
Nalo19	Purple Kahanu	Block4	NA	100	NA
Nalo19	Mohihi Ly	Block4	NA	100	NA
Poamoho	HM3	Block1	NA	0	7.692307692
Poamoho	HM4	Block1	NA	0.1818	4.545454545
Poamoho	HM12	Block1	NA	0	0

Poamoho	HM16	Block1	NA	0.0714	0
Poamoho	HM17	Block1	NA	11.59	87.5
Poamoho	HM18	Block1	NA	12	0
Poamoho	HM26	Block1	NA	0	8
Poamoho	HM32	Block1	NA	0.1481	25.92592593
Poamoho	HM34	Block1	NA	0	0
Poamoho	HM35	Block1	NA	0.0555	5.555555556
Poamoho	HM39	Block1	NA	0	0
Poamoho	HM46	Block1	NA	0.3	0
Poamoho	Okinawa	Block1	NA	0.0769	15.38461538
Poamoho	Lanikeha	Block1	NA	0	0
Poamoho	Purple Kahanu	Block1	NA	0	0
Poamoho	Mohihi Ly	Block1	NA	0	0.2
Poamoho	HM3	Block2	NA	0	11.79
Poamoho	HM4	Block2	NA	0.08	0
Poamoho	HM12	Block2	NA	0.1875	0
Poamoho	HM16	Block2	NA	0.0588	0
Poamoho	HM17	Block2	NA	0	0
Poamoho	HM18	Block2	NA	0	0
Poamoho	HM26	Block2	NA	0.041	16.66666667
Poamoho	HM32	Block2	NA	0.035	1.754385965
Poamoho	HM34	Block2	NA	0	5.555555556
Poamoho	HM35	Block2	NA	0.0212	14.89361702
Poamoho	HM39	Block2	NA	0.0439	5.494505495
Poamoho	HM46	Block2	NA	0	0
Poamoho	Okinawa	Block2	NA	0.25	0
Poamoho	Lanikeha	Block2	NA	0	0
Poamoho	Purple Kahanu	Block2	NA	0.074	22.22222222
Poamoho	Mohihi Ly	Block2	NA	0.444	0
Poamoho	HM3	Block3	NA	0.1904	5.555555556
Poamoho	HM4	Block3	NA	0	0
Poamoho	HM12	Block3	NA	0.2352	0

Poamoho	HM16	Block3	NA	0.4	5.882352941
Poamoho	HM17	Block3	NA	0.1111	1.4
Poamoho	HM18	Block3	NA	0	5.555555556
Poamoho	HM26	Block3	NA	0	8.333333333
Poamoho	HM32	Block3	NA	0	0
Poamoho	HM34	Block3	NA	0	0
Poamoho	HM35	Block3	NA	0.1176	0.375
Poamoho	HM39	Block3	NA	0.111	0.1764705882
Poamoho	HM46	Block3	NA	0.4444	0.4444444444
Poamoho	Okinawa	Block3	NA	0	0
Poamoho	Lanikeha	Block3	NA	0	0
Poamoho	Purple Kahanu	Block3	NA	0	0.4210526316
Poamoho	Mohihi Ly	Block3	NA	0.2272	0
Poamoho	HM3	Block4	NA	0	0.09090909091
Poamoho	HM4	Block4	NA	0	0.05263157895
Poamoho	HM12	Block4	NA	0	0
Poamoho	HM16	Block4	NA	0.2	0
Poamoho	HM17	Block4	NA	0	0.2
Poamoho	HM18	Block4	NA	0.3125	0
Poamoho	HM26	Block4	NA	0	0
Poamoho	HM32	Block4	NA	0.1904	0
Poamoho	HM34	Block4	NA	0	0.2857142857
Poamoho	HM35	Block4	NA	0	0
Poamoho	HM39	Block4	NA	0.12	0.125
Poamoho	HM46	Block4	NA	0.25	0
Poamoho	Okinawa	Block4	NA	0	0
Poamoho	Lanikeha	Block4	NA	0	0
Poamoho	Purple Kahanu	Block4	NA	0	0.1428571429
Poamoho	Mohihi Ly	Block4	NA	0.125	0

ENV	Line	block	lost_sprouting_curing_metrictonnes	yield_after_sprouting_In_curing_sprouting_metrictonnes
Nalo18	HM3	Block1	0.08707604786	1.063201995

Nalo18	HM4	Block1	0	0.7734880604
Nalo18	HM12	Block1	0.02713773492	1.439766855
Nalo18	HM16	Block1	0.0474417233	1.425903721
Nalo18	HM17	Block1	0.1279591077	0.2743015263
Nalo18	HM18	Block1	0	1.437481596
Nalo18	HM26	Block1	0	1.763183892
Nalo18	HM32	Block1	0.02705378423	0.7853721687
Nalo18	HM34	Block1	0.1744703031	1.221292122
Nalo18	HM35	Block1	0.220540754	1.918554823
Nalo18	HM39	Block1	0.02739012858	0.7951362551
Nalo18	HM46	Block1	0	1.427234782
Nalo18	Okinawa	Block1	NA	NA
Nalo18	Lanikeha	Block1	NA	NA
Nalo18	Purple Kahanu	Block1	NA	NA
Nalo18	Mohihi Ly	Block1	NA	NA
Nalo18	HM3	Block2	0	0.5678198687
Nalo18	HM4	Block2	0.0757898265	0.2273694795
Nalo18	HM12	Block2	0.08815919461	0.6171143623
Nalo18	HM16	Block2	0.06971434423	1.465843899
Nalo18	HM17	Block2	0	0.1646809364
Nalo18	HM18	Block2	0.03246599026	1.201982309
Nalo18	HM26	Block2	0.2941086759	1.503621617
Nalo18	HM32	Block2	0.3018535692	0.6414388345
Nalo18	HM34	Block2	0.1309395252	1.54134049
Nalo18	HM35	Block2	0.6324889747	0.7424870573
Nalo18	HM39	Block2	0.1092749503	0.3278248508
Nalo18	HM46	Block2	0	0.7554829447
Nalo18	Okinawa	Block2	NA	NA
Nalo18	Lanikeha	Block2	NA	NA
Nalo18	Purple Kahanu	Block2	NA	NA
Nalo18	Mohihi Ly	Block2	NA	NA

Nalo18	HM3	Block3	0.06675730404	0.6676464808
Nalo18	HM4	Block3	0.02576341761	0.4895049345
Nalo18	HM12	Block3	0.03550301414	0.6041909344
Nalo18	HM16	Block3	0.1241913835	1.117722452
Nalo18	HM17	Block3	0.04742810968	0
Nalo18	HM18	Block3	0.1153046146	0.4324607756
Nalo18	HM26	Block3	0.04456872165	0.713402735
Nalo18	HM32	Block3	0.05826562304	0.7873892833
Nalo18	HM34	Block3	0.1450334028	1.088243832
Nalo18	HM35	Block3	0.6864633345	0.6864633345
Nalo18	HM39	Block3	0.01766161324	0.5308356923
Nalo18	HM46	Block3	0.1035220962	0.9316988658
Nalo18	Okinawa	Block3	NA	NA
Nalo18	Lanikeha	Block3	NA	NA
Nalo18	Purple Kahanu	Block3	NA	NA
Nalo18	Mohihi Ly	Block3	NA	NA
Nalo19	HM3	Block1	NA	NA
Nalo19	HM4	Block1	NA	NA
Nalo19	HM12	Block1	NA	NA
Nalo19	HM16	Block1	NA	NA
Nalo19	HM17	Block1	NA	NA
Nalo19	HM18	Block1	NA	NA
Nalo19	HM26	Block1	NA	NA
Nalo19	HM32	Block1	NA	NA
Nalo19	HM34	Block1	NA	NA
Nalo19	HM35	Block1	NA	NA
Nalo19	HM39	Block1	NA	NA
Nalo19	HM46	Block1	NA	NA
Nalo19	Okinawa	Block1	NA	NA
Nalo19	Lanikeha	Block1	NA	NA
Nalo19	Purple Kahanu	Block1	NA	NA

Nalo19	Mohihi Ly	Block1	NA	NA
Nalo19	HM3	Block2	NA	NA
Nalo19	HM4	Block2	NA	NA
Nalo19	HM12	Block2	NA	NA
Nalo19	HM16	Block2	NA	NA
Nalo19	HM17	Block2	NA	NA
Nalo19	HM18	Block2	NA	NA
Nalo19	HM26	Block2	NA	NA
Nalo19	HM32	Block2	NA	NA
Nalo19	HM34	Block2	NA	NA
Nalo19	HM35	Block2	NA	NA
Nalo19	HM39	Block2	NA	NA
Nalo19	HM46	Block2	NA	NA
Nalo19	Okinawa	Block2	NA	NA
Nalo19	Lanikeha	Block2	NA	NA
Nalo19	Purple Kahanu	Block2	NA	NA
Nalo19	Mohihi Ly	Block2	NA	NA
Nalo19	HM3	Block3	NA	NA
Nalo19	HM4	Block3	NA	NA
Nalo19	HM12	Block3	NA	NA
Nalo19	HM16	Block3	NA	NA
Nalo19	HM17	Block3	NA	NA
Nalo19	HM18	Block3	NA	NA
Nalo19	HM26	Block3	NA	NA
Nalo19	HM32	Block3	NA	NA
Nalo19	HM34	Block3	NA	NA
Nalo19	HM35	Block3	NA	NA
Nalo19	HM39	Block3	NA	NA
Nalo19	HM46	Block3	NA	NA
Nalo19	Okinawa	Block3	NA	NA
Nalo19	Lanikeha	Block3	NA	NA

Nalo19	Purple Kahanu	Block3	NA	NA
Nalo19	Mohihi Ly	Block3	NA	NA
Nalo19	HM3	Block4	NA	NA
Nalo19	HM4	Block4	NA	NA
Nalo19	HM12	Block4	NA	NA
Nalo19	HM16	Block4	NA	NA
Nalo19	HM17	Block4	NA	NA
Nalo19	HM18	Block4	NA	NA
Nalo19	HM26	Block4	NA	NA
Nalo19	HM32	Block4	NA	NA
Nalo19	HM34	Block4	NA	NA
Nalo19	HM35	Block4	NA	NA
Nalo19	HM39	Block4	NA	NA
Nalo19	HM46	Block4	NA	NA
Nalo19	Okinawa	Block4	NA	NA
Nalo19	Lanikeha	Block4	NA	NA
Nalo19	Purple Kahanu	Block4	NA	NA
Nalo19	Mohihi Ly	Block4	NA	NA
Poamoho	HM3	Block1	0.204485867	2.453830404
Poamoho	HM4	Block1	0.03506539534	0.7363733023
Poamoho	HM12	Block1	0	3.293618728
Poamoho	HM16	Block1	0	1.810758385
Poamoho	HM17	Block1	0.5238683566	0.07483833665
Poamoho	HM18	Block1	0	1.800511571
Poamoho	HM26	Block1	0.3667773815	4.217939887
Poamoho	HM32	Block1	0.2011411602	0.5746890291
Poamoho	HM34	Block1	0	1.579473159
Poamoho	HM35	Block1	0.18322279	3.11478743
Poamoho	HM39	Block1	0	2.230877752
Poamoho	HM46	Block1	0	1.548732717
Poamoho	Okinawa	Block1	0.287586401	1.581725206

Poamoho	Lanikeha	Block1	0	0.05708939128
Poamoho	Purple Kahanu	Block1	0	1.248647456
Poamoho	Mohihi Ly	Block1	0.002020086154	1.008022991
Poamoho	HM3	Block2	0.1983008789	1.483640418
Poamoho	HM4	Block2	0	1.380392205
Poamoho	HM12	Block2	0	2.528035353
Poamoho	HM16	Block2	0	1.996664864
Poamoho	HM17	Block2	0	0
Poamoho	HM18	Block2	0	1.052494162
Poamoho	HM26	Block2	0.4489080341	2.24454017
Poamoho	HM32	Block2	0.0430417543	2.410338241
Poamoho	HM34	Block2	0.07823361028	1.329971375
Poamoho	HM35	Block2	0.1613328133	0.9219017907
Poamoho	HM39	Block2	0.1079373952	1.856523197
Poamoho	HM46	Block2	0	1.23254532
Poamoho	Okinawa	Block2	0	0.1756596655
Poamoho	Lanikeha	Block2	0	0.06294471347
Poamoho	Purple Kahanu	Block2	0.1737078914	0.60797762
Poamoho	Mohihi Ly	Block2	0	0
Poamoho	HM3	Block3	0.07839625812	1.332736388
Poamoho	HM4	Block3	0	1.217907014
Poamoho	HM12	Block3	0	1.945430795
Poamoho	HM16	Block3	0.1569742991	2.511588786
Poamoho	HM17	Block3	0.00174195835	0.1226836381
Poamoho	HM18	Block3	0.1230430898	2.091732526
Poamoho	HM26	Block3	0.2844710694	3.129181764
Poamoho	HM32	Block3	0	3.044767535
Poamoho	HM34	Block3	0	0.8197451056
Poamoho	HM35	Block3	0.005577194378	1.48167464
Poamoho	HM39	Block3	0.003303951649	1.868935316
Poamoho	HM46	Block3	0.01364290068	3.056009753

Poamoho	Okinawa	Block3	0	0.6235918125
Poamoho	Lanikeha	Block3	0	0.004391491637
Poamoho	Purple Kahanu	Block3	0.007704371293	1.822083811
Poamoho	Mohihi Ly	Block3	0	1.469685868
Poamoho	HM3	Block4	0.001531699053	1.683337259
Poamoho	HM4	Block4	0.000703409099	1.335773879
Poamoho	HM12	Block4	0	2.342128873
Poamoho	HM16	Block4	0	1.190094234
Poamoho	HM17	Block4	0.0002459235316	0.1227158423
Poamoho	HM18	Block4	0	1.466758207
Poamoho	HM26	Block4	0	2.68173756
Poamoho	HM32	Block4	0	0.5694300823
Poamoho	HM34	Block4	0.003826871283	1.335578078
Poamoho	HM35	Block4	0	1.924937168
Poamoho	HM39	Block4	0.002825192954	2.25732917
Poamoho	HM46	Block4	0	1.686332789
Poamoho	Okinawa	Block4	0	0.4698896052
Poamoho	Lanikeha	Block4	0	0.0673362051
Poamoho	Purple Kahanu	Block4	0.002429958706	1.698541135
Poamoho	Mohihi Ly	Block4	0	3.51319331